Department of Horticulture
College of Agriculture, Dapoli

NOTES

Course: HORT 111

Fundamentals of Horticulture

Compailed by
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Course Title: Fundamentals of Horticulture **Course No: HORT 111**

Year: First **Semester: I** **Credit hours: 2(1+1)**

Theory: Horticulture - Its definition and branches, importance and scope, horticultural and botanical classification, climate and soil for horticultural crops, plant propagation methods and propagating structures, seed dormancy, seed germination, principles of orchard establishment, principles and methods of training and pruning, juvenility and flower bud differentiation, unfruitfulness, pollination, pollinizers and pollinators, fertilization and parthenocarpy, medicinal and aromatic plants, importance of plant bio-regulators in horticulture, irrigation methods, fertilizer application in horticultural crops.

Practical: Identification of garden tools. Identification of horticultural crops. Preparation of seed bed/nursery bed. Practice of sexual and asexual methods of propagation including micro-propagation. Layout and planting of orchard. Training and pruning of fruit trees. Preparation of potting mixture. Fertilizer application in different crops. Visits to commercial nurseries/orchard.

Suggested Reading:

- Chadha K. L. (ICAR), 2002. *Handbook of Horticulture*. ICAR, New Delhi.
- D. K. Salunkhe and S.S. Kadam, 2013. *A handbook of Fruit Science and Technology*. CRC Press.
- Denisen E.L.,1957. *Principles of Horticulture*. Macmillan Publishing Co., New York.
- Edmond,J.B, Sen,T.L, Andrews,F.S and Halfacre R.G., 1963. *Fundamentals of Horticulture*. Tata Mc Graw Hill Publishing Co., New Delhi.
- Gardner/Bardford/Hooker. J.R., 1957. *Fundamentals of Fruit Production*. Mac Graw Hill Book Co., New York.
- Jitendra Singh, 2002. *Basic Horticulture*. Kalyani Publishers, Hyderabad.
- Jitendra Singh, 2011. *Basic Horticulture*. Kalyani Publications, New Delhi.
- K.V.Peter, 2009. *Basics Horticulture.* New India Publishing Agency
- Kausal Kumar Misra and Rajesh Kumar, 2014. *Fundamentals of Horticulture*. Biotech Books.
- Kumar, N., 1990. *Introduction to Horticulture*. Rajyalakshmi publications, Nagarcoil, Tamilnadu
- Neeraj Pratap Singh, 2005. *Basic concepts of Fruit Science* 1st Edn. IBDC Publishers.
- Prasad and Kumar, 2014. *Principles of Horticulture* 2nd Edn. Agrobios (India).

- S. Prasad and U. Kumar, 2010. *A handbook of Fruit Production*. Agrobios (India).

Lesson/Course Plan

Lecture No.	Topics	Weightage (%)
1	Horticulture-Its definition and branches, importance and scope	10
2-3	Horticultural and botanical classification	10
4	Climate and soil for horticultural crops	10
5- 6	Plant propagation-methods and propagating structures	10
7	Seed dormancy, Seed germination	10
8	Principles of orchard establishment	10
9	Principles and methods of training and pruning,	10
10	Juvenility and flower bud differentiation	05
11	Unfruitfulness	10
12	Pollination, pollinizers and pollinators, Fertilization and parthenocarpy	10
13	Medicinal and aromatic plants: Introduction	5
14	Use of plant bio-regulators in horticulture	10
15	Irrigation method & fertilizers application in Horticultural crops	5
16	Recommendation of Joint Agresco	5
	Total	**120**

Practical Schedule

Practical No.	Topics
1- 2	Identification of horticultural crops
3	Identification of garden tools
4	Preparation of seed bed/nursery bed
5	Practice of sexual method of propagation
6- 8	Practice of asexual methods of propagation Cutting, Layering, Budding, Grafting
9	Layout and planting of orchard plants
10	Training and pruning of fruit trees
11	Preparation of potting mixture, potting and repotting
12- 14	Fertilizer application in different crops
15-16	Visits to commercial nurseries, orchard

Fundamentals of Horticulture

What is horticulture? The term Horticulture is derived from two Latin words i.e. **Hortus** meaning garden or enclosure and **Cultra** meaning cultivation. So, horticulture literally means garden culture or culture of garden crops. The term **Agriculture** refers broadly to the technology of raising plants and animals. On the other hand **Horticulture** which is a part of agriculture is concerned with the raising of so called garden crops. In olden days staple (food) crops (Paddy, Maize, Wheat etc.) were grown in open fields on a large scale, while some crops of special interest like fruits, vegetables, flowers etc. were grown in the back yard of houses in an enclosure. In cases where fruits, vegetables and flowers were grown in areas other than backyards, they are protected by erecting walls, by raising live fences, non-live fences etc. i.e. they are enclosed. The term Horticulture in the original sense referred to the cultivation of crops within the protected enclosure, which is often called as a garden (Crops grown in a protected enclosure). So, the culture of crops in gardens is referred as **Horticulture**.

At present, fruits, vegetables, flowers etc. are grown not only with in the back yards, but also in large areas in open fields on a commercial scale. Traditionally garden crops include fruits, vegetables and flowers. But today‘s horticulture deals not only the fruits, vegetables and flowers but also other important crops like spices, condiments, plantation crops, medicinal and aromatic plants etc,. Besides cultivation of these crops, present day horticulture deals with the utilization and improvement of these crops. Hence, modern horticulture may be defined as a part of agricultural science, which deals with the production, utilization, and improvement of fruits, vegetables, flowers, ornamentals, plantation crops, medicinal and aromatic plants etc.

Divisions of horticulture: Horticulture crops include fruits, Vegetables, flowers, plantation crops, Spices, condiments, Medicinal and Aromatic crops etc. In addition to these, Horticulture also deals with raising of trees for shade, ornamental and avenue purposes, planning and raising of ornamental gardens, parks and raising of seed and planting material. Further, horticulture also deals with the utilization of horticulture produce and improvement of horticulture crops. Hence, based upon the crops dealt and also their purpose and utilization, the branch of horticulture is sub-divided in to the following divisions for convenience.

Fruit Science or Pomology: It is derived from two words i.e. **Pomum** meaning **fruit** and **Logos** meaning **discourse or study**. So, pomology is study or cultivation of fruit crops. **E.g.** Mango, Sapota, Guava, Grape, Banana etc.

Fruit: It is a developed and matured ovary with or without accessory parts and which is generally eaten as raw.

Vegetable science or Olericulture: It is derived from two words i.e. **Oleris** meaning **Potherb** and **Cultra** meaning cultivation. So, Olericulture literally means **potherb** cultivation. In the present days it is broadly used to indicate the cultivation of vegetables.**Eg.** Brinjal, Okra, Tomato, Pumpkin etc.

Vegetable: It is any part of the herbaceous plant that is generally used after cooking as a principal part of the meal.

Differences between fruits and vegetables

Vegetables	X	Fruits
Most of the vegetables are annuals	:	Fruit plants are perennial in nature
Mostly majority of them are sexually propagated	:	Fruit plant are sexually and asexually propagated
Cultivation of vegetable is seasonal and special techniques like pruning and training are generally not required	:	Fruit plants require special practices like training and pruning and are required seasonally.
Vegetable plants are generally non-woody	:	Fruit plants are generally woody in nature
All parts of the plant are edible	:	Only fruit is edible but sometimes false fruit also edible (eg. Fleshy thalamus of apple)
Generally consumed after cooking	:	Mostly consumed raw after ripening

Floriculture: It is derived from two words i.e. Florus meaning flower and Cultra meaning cultivation. So floriculture means study of flower crops. In this there are again two sub-divisions.

Commercial floriculture: Deals with the cultivation of flower crops grown on commercial scale for profit (Income). **E.g.:** Rose, Jasmine, Carnation, Aster, and Marigold etc.

Ornamental floriculture: It deals with the raising of flower crops for ornamental, pleasure and fashion purposes. **E.g.:** Dahlia, Zinnia, Cosmos, Hibiscus, Balsam, Nerium, Poinsettia, Hollyhock, Gerbera, and Gaillardia etc.

Arboriculture: This branch deals with the raising of perennial trees meant for shade, avenue or ornamental purposes. **Eg.**Polyalthia, Spathodea, Cassia, Gulmohar etc.

Plantation crops: Are those crops, which are cultivated in an extensive scale in large contiguous areas, owned and managed by an individual or a company and whose produce is utilized only after processing. **Eg.** Coffee, Tea, Rubber, Coconut, Cocoa, etc.

Spices and condiments: This branch deals with the cultivation of crops whose produce is used mainly for seasoning and flavouring dishes. Both spices and condiments contain essential oils, which provide **aroma, flavour and taste** and they are of little nutritive value.

Spices: Are those plants the products of which are made use of as food adjuncts to add aroma and flavour. **Eg.** Pepper, Cardamom, Clove, Cinnamon, All spice etc.

Condiments*:* Are those plants the products of which are made use of as food adjuncts to add taste only. **Eg**.Turmeric,Ginger,Red chillies,Onion,Garlic etc.

Medicinal and aromatic plants: It deals with the cultivation of medicinal plants, which provide drugs and aromatic crops which yields aromatic (essential) oils.

Medicinal plants- are those plants, which are rich in secondary metabolites and are potential sources of drugs. The secondary metabolites include alkaloids, glycosides, coumarins, flavonoides and steroids etc. **Eg.** Periwinkle, Opium, Menthi, Cinchona, Dioscorea Yam, Belladona, Senna, Sarpagandha, Aswagandha, Tulasi etc.

Aromatic plants- are those plants, which possesses essential oils in them. The essential oils are the odoriferous steam volatile constituents of aromatic plants. **Eg**. Lemon grass, Citronella, Palmrosa, Vetiver, Geranium, Davanam, Lavendor etc.

Post Harvest technology: It deals with the processing and preservation of produce of horticulture crops.

Landscape gardening: It deals with the planning and execution of ornamental gardens, parks, landscape gardens etc.

Nursery and seed production: It deals with the production of seeds and planting material of horticulture crops on commercial basis.

Plants grown for aesthetic value are also included in horticulture. Though crops like potato, cowpea and several condiments are grown as field crops they are included under horticultural crops when they are grown as vegetables in small areas.

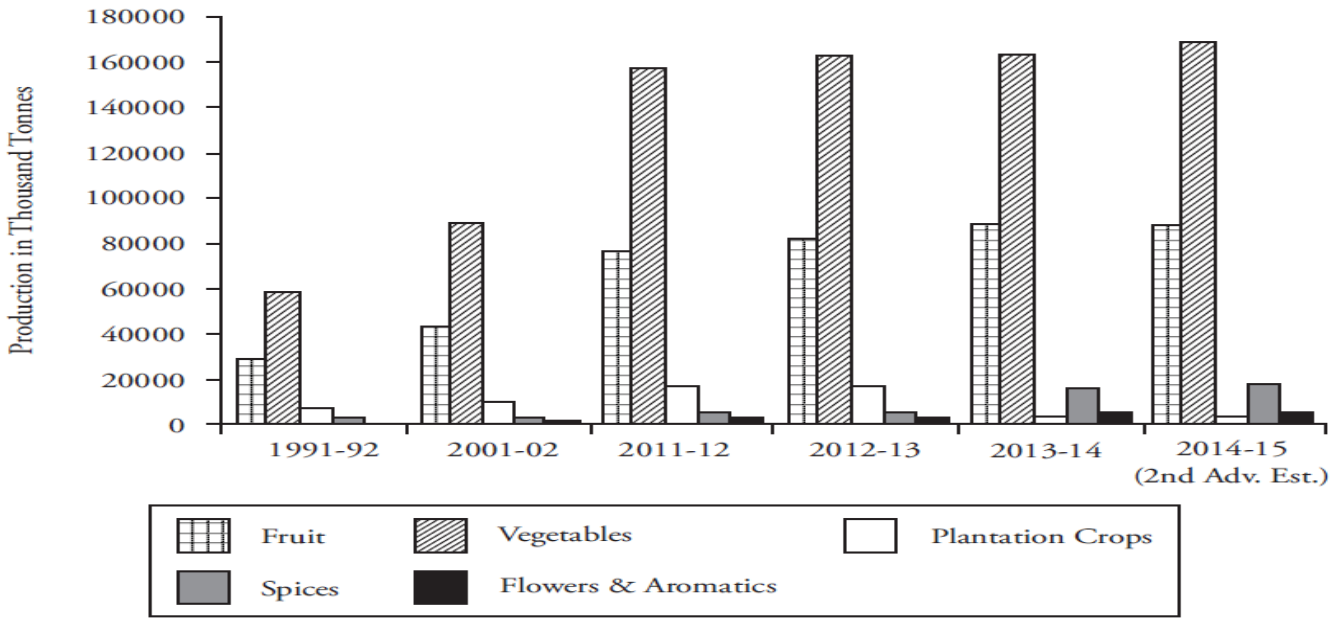


Figure 2.1 Production of Various Horticultural Crops over the Years: Graph

Role of horticultural crops in human nutrition

From human nutrition point of view horticulture is most important to our daily living. Many of the horticulture crops and their products find place in our meals and diet. Human body requires vitamins, minerals, proteins, energy etc. for its health. All these are supplied by horticultural crops. Fruits and vegetables are the chief sources of vitamins, minerals, carbohydrates, fats, proteins etc. Fruits and vegetables are recognized as **protective foods** as they are necessary for the maintenance of human health.

Vitamins: These are the important constituents of fruits and vegetables and are indispensable part of human diet. Although required in very minute quantities, they are absolutely essential for the maintenance of health. The deficiency of any vitamin from the diet for considerable period may lead to diseased state or disorder conditions. Fruits and vegetables supply several vitamins.

Vitamins	**Sources**	
***Vitamin-A*:** It is essential for normal growth, reproduction and maintenance of health and vigour. It affords protection against cold and influenza and prevents night blindness. The deficiency of this vitamin results in cessation of growth in young children, night blindness, drying up of tear glands in the eyes, eruption of skin (Rashes on the skin) and brittleness of the teeth	***Fruits*** Mango, Papaya, Dates, Jackfruit, Walnut etc.	***Vegetables*** Greens like palak, spinach amaranthus, cabbage, fenugreek, carrot, lettuce, peas, tomato etc.
Vitamin B1 (Thiamine): Tones the nervous system and helps in proper functioning of the digestive tract. Its deficiency in human diet results in **Ber-beri**, paralysis, loss of sensitivity of skin, enlargement of heart, loss of appetite **,**loss of weight and fall in body temperature.	Orange, jack fruit, pineapple, cashew nut, walnut, dry apricot, almond, banana etc.	Green chilli, beans, onion, sweet potato, tomato (red), leaves of colocasia.
Vitamin B2* (*Riboflavin): This vitamin is required for body growth and health of the skin. The deficiency of this vitamin causes sore throat, anorexia cataract, and loss of appetite and body weight and also development of swollen nose.	Bael, apricot, pomegranate, papaya, litchi, banana, pear etc.	Cabbage, cauliflower, potato, peas & beans, methi, green chillies, lettuce, asparagus, leafy vegetables etc,.
Vitamin -C (Ascorbic Acid): This vitamin promotes general health and healthy gums, prevents scurvy disease which is characterized by pain in the joints and swelling of limbs (rheumatism), bleeding of gums, tooth decay and keeps the blood vessels in good condition.	Amla**,** guava, ber, citrus, strawberry, pineapple etc.	Tomato, palak, menthi, cabbage, green chillies, spinach, potatoes, peas and beans and carrot etc.
Vitamin-D: This vitamin is necessary for building up of bones, preventing rickets and diseases of teeth.		All green leafy vegetables are rich in this vitamin.
Vitamin-E: Has an important effect on the generative functions and promotes fertility.		Green lettuce and other green vegetables.
Vitamin-K: This vitamin prevents blood clotting		All green leafy vegetables
Minerals		
Calcium: It is essential for development of bones regulation of heartbeat, controlling blood clots	Acid lime, Orange, Fig, Dried apricots, wood apple etc.	Cabbage, greens, beans, carrot, onions, peas, tomatoes, agati, spinach drumstick leaves etc.
Iron: It is required for production of haemoglobin and it is constituent of red blood corpuscles. Its deficiency causes anaemia, smooth tongue, pale lips, eyes and skin and frequent exhaustion.	Custard apple, Guava, Pineapple, Straw berry, Grape, Black currents, dried dates etc.	Carrot, Drumstick leaves, beans and agati etc.
Phosphorous: It is essential for maintaining the moisture content of tissues and for development of bones	Guava, Grape, Jackfruit, Passion fruit, Orange	Carrot, Chilli, Drumstick leaves, Beans, cucumber and onion.
Proteins: These are bodybuilding foods. These are essential for growth of the body. The deficiency of proteins in the body causes retarded growth and	Most of the fruits are low in proteins except Guava and Banana	Peas and beans are rich in proteins.

increases susceptibility to diseases and causes lethargy		

Enzymes: These are required for controlling several metabolic activities in the body**. Sources:** Papaya-Papain and Pineapple-Bromelin.

Fibre and roughages (Cellulose and pectin): Fruits and vegetables supply roughages These are required for digestion and prevention of constipation. **Sources:** Fruits contain low content of fibre. Guava and anola are better sources compared to other fruits. Leafy vegetables are rich in fibre content

Energy foods: Fruits and vegetables contain Carbohydrates and fats there by supply energy to human body. Those fruits (Banana, Dates, Apple etc.) and vegetables (Potatoes, Sweet potato, Beans, Peas etc.), which contain Carbohydrates, are called as **energy Foods.** Nut fruits like Walnut, Cashew nut, almond. etc supplies proteins besides energy.

Present Horticulture Status: Fruit crops cover an area of 7.216 m ha and vegetable crops 9.396 m ha. Accordingly, 88.98 M ton of fruits and 162.897 M ton of vegetables are produced in the country annually (Indian Horticulture Database, 2015).

- To meet out the projected demand of population by 2020 AD about 50 MT of fruits and 143 MT of vegetables would be required. Therefore by 2020 A.D. At present India is self sufficient but it is essential to maintain production in changing climate.
- Requirements of export and processing industry further add to the requirements of horticultural produce. In view of these, there is lot of scope of increasing production and potentiality of horticulture crops.
- Apart from fruits and vegetables, floriculture industry in India comprising of florist trade, nursery plants, potted plants, seed and bulb products is being observed as *sunrise* industry. There is roaring business of flowers in almost all metropolitan cities of the different states.
- The developed flower market in the country during 2013-14 is with area of 2.55 lakh ha with a production of 17.54 lakh MT loose flowers and 5.43 lakh MT cut flowers. The traditional flowers are grown on a large area on a commercial scale. These flowers are mostly grown for loose flower purpose. Area under cut flowers like rose, chrysanthemum, gladiolus, carnation and orchids is increasing day by day.
- Plantation crops are another potential sector with lot of opportunities for employment generation, foreign exchange earnings and overall supporting livelihood sustenance of mankind at large. These plantaion crops form the mainstay of lively hood in coastal areas of the country where predominating stands of plantation crops are found.
- Coconut has so much importance in the country that the state Kerala receives its very name on the basis of coconut, the Malayalam name of which is *Kera*. These cover an area of 36.75 lakh ha with a production of 163.01 lakh MT.
- India is considered to be motherland of spices. These cover an area of 31.63 lakh ha with a production of 59.08 lakh MT.

Importance of horticulture in the national economy

1. Horticultural produces contribute to national wealth. They are the important exportable commodities in many countries. In India also through export of horticultural produces our country is earning foreign exchange.

India exporting **flowers** to America, Netherlands, Germany, Japan, UK, **Onions** to Malayasia, UAE, Singapore, Srilanka and Bangladesh. **Vegetables** to Srilanka, America, UAE, Spain, Saudi Arabia, Bangladesh, U.K., Kuawait, **Fresh grapes** to UK, Netherlands, UAE, Bangladesh, Germany, **Fresh fruits** to Bangladesh, UAE, Saudi Arabia, UK and Srilanka. **Processed vegetables** to Egypt, Srilanka, UAE, America and Turkey and **Mango pulp** to Saudi Arabia, UAE, Netherlands, Kuwait and Germany. **Pickles and Chutneys** to UK, America, UAE, Spain etc.

2. Horticulture is a mother for many axillary industries like canning industries and processing industries etc. Several agro industries, based on horticultural products are being established there by solving the unemployment problem to some extent. Eg. Rubber, Coir (Coconut) and sago (Tapioca) industries

3. Horticultural crops provide gainful employment for small farmers and agricultural labour throughout the year. One hectare of fruit production generates 860 man-days per annum as against 143 man-days for cereal crops. Some industrial attribute crops and cultural intensive crops like grape, banana and pineapple, generate much large employment ranging from 1,000 to 2,500 man-days per hectare.

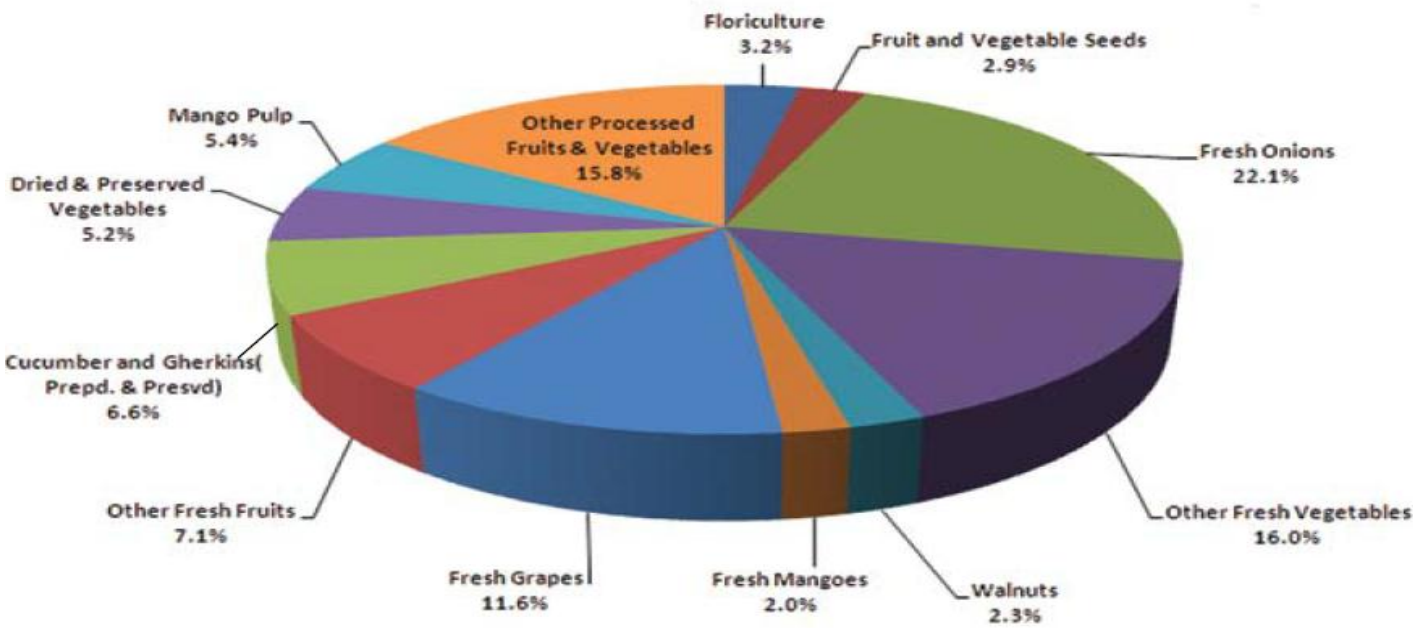
EXPORT OF HORTICULTURE PRODUCE FROM INDIA

VALUE IN LAKH AND QUANTITY IN MT

Product	2011-12		2012-13		2013-14	
	Qty	Value	Qty	Value	Qty	Value
Floriculture						
Floriculture	30926.02	36532.15	27121.86	42344.6	22485.21	45590.62
Fruits & Vegetables Seeds	15205.81	28776.35	17168	34772.39	17816.7	41053.76
Total	**46131.83**	**65308.5**	**44289.86**	**77116.99**	**40301.91**	**86644.38**
Fresh Fruits & Vegetables						
Fresh Onions	1309924.82	172299.8	1666872.6	196662.66	1482498.58	316961.25
Other Fresh Vegetables	734178.83	131048.2	768627.2	151633.56	953731.22	229332.27
Walnuts	5841.56	23108.4	5295.47	19983.57	6726.36	32453.5
Fresh Mangoes	63441.29	20974.3	55584.99	26471.78	41279.97	28542.85
Fresh Grapes	108584.56	60288.15	172744.42	125942.78	192616.91	166647.45
Other Fresh Fruits	270437.2	75541.11	263970.29	77975.78	240552.45	102159.21
Total	**2492408.26**	**483259.96**	**2933094.97**	**598670.13**	**2917405.49**	**876096.53**
Cucumber and Gherkins(Prepd. & Presvd)	258603	74503.45	238624.89	85659.18	218749.79	95520.18
Dried & Preserved Vegetables	64794.09	52678.47	68520.25	63795.76	56158.38	74271.74
Mango Pulp	150499.06	62082.91	147815.69	60855.73	174860.33	77294.76
Other Processed Fruits & Vegetables	274807.05	157759.82	269217.26	173305.54	287384.61	226660.26
Total	**748703.2**	**347024.65**	**724178.09**	**383616.21**	**737153.11**	**473746.94**
Grand Total	**3287243.29**	**895593.11**	**3701562.92**	**1059403.33**	**3694860.51**	**1436487.85**

Source: Apeda Website January 2015

COMMODITYWISE SHARE OF EXPORTS OF HORTICULTURAL PRODUCTS FROM INDIA 2013-14



Importance of horticulture in India: ***Horticulture is important for health, wealth, hygiene and happiness.***

- As a source of variability in produce. Financial stability to farmers (continuous flow of money)
- As a source of nutrients, vitamins, minerals, flavour, aroma, alkaloids, oleoresins, fibre, etc. (protective food)
- As a source of medicine.
- As an economic proposition as they give higher returns per unit area in terms of energy, money, job, etc. (0.6 ha Wheat = 0.02 Ha Mango)
- Employment generation - fruit crops requires 860 man days/annum as against 143 man days/annum for cereal crops where as the crops like grapes, banana and pineapple needs 1000- 2500 man days per annum.
- Effective utilization of waste land through cultivation of hardy fruits and medicinal plants.
- As a substitute for family income being the component of home garden/ kitchen garden.
- As a foreign exchange earner, has higher share compare to agriculture crops.
- As an input for industry being amenable to processing, especially fruit and vegetable preservation industry.
- Aesthetic consideration and protection of the environment. trees helps to reduce soil erosion
- Religious significance in the country.
- Can be grown in rainfed condition (87% in Maharashtra)
- Mixed, multi-storey, intercropping, crop diversification
- It enhances land value and creates better purchasing power for those who are engaged in this industry.

Scope of horticulture in India: Like any other things, scope of horticulture depends on incentive it has for the farmers, adaptability of the crops, necessity and facilities for future growth through inputs availability and infrastructure for the distribution of produce/marketing etc.

1. **Incentive for the farmer:**

- The biggest incentive for the farmer is money.
- Horticultural crops provide more returns in terms of per unit area of production, export value, value addition compared to agricultural crops.

2. **Adaptability:**

- India is bestowed with a great variety of climatic and edaphic conditions as we have climates varying from tropical, subtropical, temperate and within these humid, semi-arid, arid, frost free temperate etc.
- Likewise we have soils from loam, alluvial, laterite, medium black, rocky shallow, heavy black, sandy etc., and thus a large number of crops can be accommodated with very high level of adaptability. Thus, there is lot of scope for horticultural crops.

3. **Necessity:**

- After having achieved the self sufficiency in food, nutritional security for the people of the country has become the point of consideration/priority.
- To meet the nutritional requirement in terms of vitamins and minerals horticulture crops are to be grown in sufficient quantities to provide a bare **minimum of 85 g of fruits** and **200 g of vegetables per head per day** with a population of above 120 crores.
- Good land is under pressure for stable food, industry, housing, roads and infrastructure due to population explosion and only wasteland had to be efficiently utilized where cultivation of annuals is a gamble due to restricted root zone and their susceptibility of abiotic stress. These lands can be best utilized to cultivate hardy horticultural crops like fruits and medicinal plants.
- At present *our share in international trade of horticultural commodities is less than one per cent of total trade*. Moreover, these commodities (spices, coffee, tea etc.,) fetch 10-20 times more foreign exchange per unit weight than cereals and therefore, taking advantage of globalization of trade, nearness of big

market and the size of production, our country should greatly involve in international trade which would provide scope for growth.

4. Export value:

- Among fresh fruits-mangoes and grapes; in vegetables- onion and potato; among flowers, roses; among plantation - cashewnut, tea , coffee, coconut, arecanut, and spice crops like black pepper, cardamom, ginger, turmeric, chillies, etc., constitute the bulk of the export basket.
- *European* and *gulf* countries are major importer of horticultural produce.
- In the recent past communication and transport system have improved, investment in food industry has increased which will support growth of horticulture through quick deliverance and avoidance of waste.

5. **Reasons for scope of Horticulture in India are:**

- To exploit the great variability of agro climatic conditions in the country.
- To meet the need for fruits, vegetables, flowers, spices, beverages in relation to population growth based on minimum nutritional security and for other needs.
- To meet the requirement of processing industry. Systematic approach to reduce post harvest losses (infrastructure facilities)
- To substitute import and increase export.
- Diversification of agriculture (area expansion)
- To improve the economic conditions of the farmers and to engage more labourers to avoid the problem of unemployment.
- To protect environment.

6. Upgradation of production technology – yield & quality

- New varieties, rootstock, healthy planting material, new machinery, etc

Horticultural zones of India

India has diversified climates right from temperate to tropical climates. So, India has been divided into 3 horticultural zones. They are **Tropical Zone, Sub-Tropical Zone, Temperate Zone**

Tropical zone: Entire South India below the Vindhya hills comes under this zone. This zone is again sub-divided in to 3 sub-zones. They are **Central tropical, Southern tropical, Coastal tropical humid zone**

Central tropical zone: States of Maharastra, Orissa, Southern part of Madhya Pradesh (Chattishgarh) and Telengana area of Andhra Pradesh comes under this zone. **Fruit crops recommended:** Mango, Cashew, Citrus, (Sweet Orange, Mandarin orange, and limes), Grape, Guava, Sapota, Banana, Sithapahal, Fig, Ber, Pomegranate, Jamun, and Jackfruit.

Southern tropical zone: Andhra Pradesh excluding Telengana, Tamilnadu, Kerala and Karnataka states comes under this zone. **Fruit crops recommended:** Mango, Coconut, Banana, Cashew, Sapota, Pineapple, Mangosteen, Breadfruit, Jackfruit, Sitaphal, Areca nut, Rubber, Pepper, Turmeric, Clove, Nutmeg, Cocoa, Coffee, Citrus (Sweet Orange, Mandarin orange, and limes).

Coastal tropical humid zone: Areas covering all along the coast of different states of peninsular India up to about 160 km inside to the sea shore line. The climate will be always humid and warm. Temperature will not be mild in winter when compared to southern tropical zone. **Fruit crops recommended:** Coconut, Banana, Cashew, Jackfruit, Mango, and Pineapple.

Sub-tropical zone: The area above the Vindhya hills comes under this zone. Occasionally frost occurs in this zone. This zone is sub-divided into two sub-zones basing on the direction. They are:

North-Western Subtropical zone: States like Rajasthan, Punjab, Haryana, Gujarat, Parts of Bihar, U.P, M.P and west Bengal comes under this zone. **Fruit crops recommended:** Litchi, citrus (sweet orange, mandarin oranges), dates, guava, sapota, Papaya, phalsa, fig are some typical subtropical fruits grown but other tropical fruits like Mango, jack, banana can also be grown etc.

North-eastern sub-tropical zone: Areas like parts of UP, Bihar, West Bengal, Assam, Meghalaya, Manipur, Nagaland, Mizoram, Arunachal Pradesh, and Tripura. **Fruit crops recommended:** Litchi, Citrus (Sweet Orange, Mandarin oranges), Dates, Guava, Sapota, Papaya, Phalsa, Fig, Mango etc.

Temperate zone: Areas comes in this zone are Jammu and Kashmir, Kulu, Katrain, Kangra valleys of Punjab, parts of Himachal Pradesh and kuman hills and also high altitude regions in South India-Nilagiris and Palani hills of TamilNadu. This zone frequently experiences frosts.

This zone is further sub-divided in to two sub zones based on elevation. They are: **Higher elevation and Lower elevation**

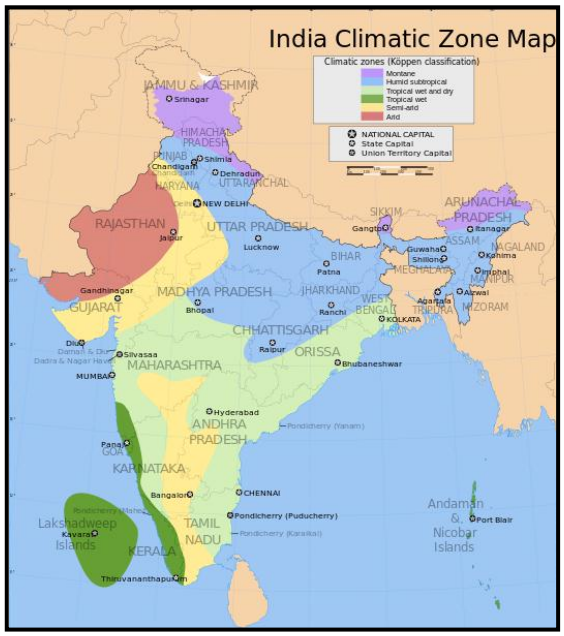
Higher elevation: Elevation ranges from 1500—2500 m MSL. **Fruit crops recommended:** Apple, Pears, Walnut, Almond, Cherry and Strawberry etc.

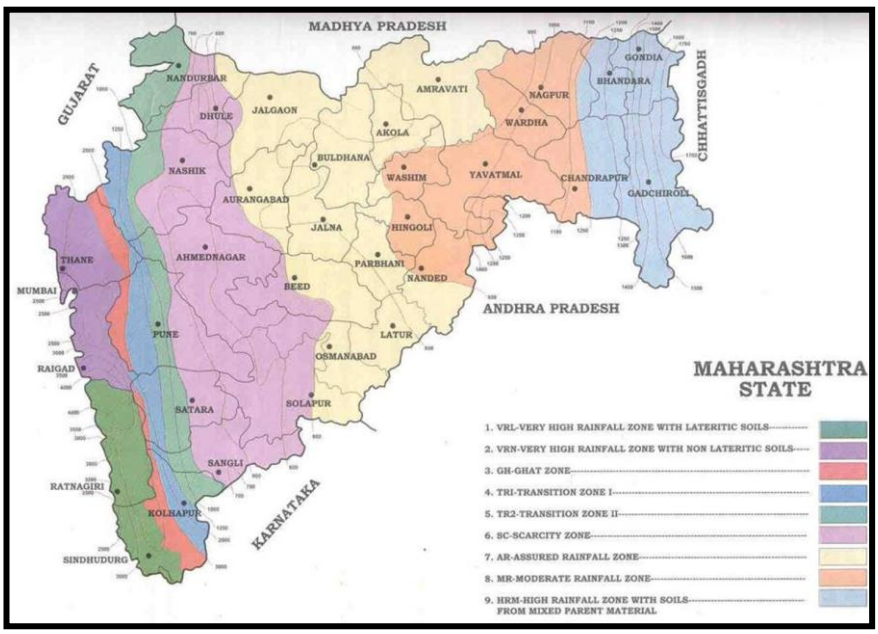
Lower elevation: Elevation ranges from 1200—1500 m MSL. **Fruit crops recommended:** Peaches, Persimmons, Japanese plum etc.

Exception of cultivation in Temperate Zones: Although Peach is a temperate fruit crop, a no. of varieties like Sharbati, Honey stone, Sunred and Safeda can be successfully grown in the northern plains of subtropical zone. Similarly Rome beauty an apple variety is grown around Bangalore. Elevation is not only the factor which decides the prospects of fruit cultivation in temperate zone. Other factors like hail storms, rainfall etc which should also be considered for selection of site for fruit cultivation in temperate zone. Eg. Simla and Solan at 2100 and 1400 m of elevation from sea level respectively. But they are not suitable for growing fruits because of hail storms. But Kulu valley and Kotagarh regions in Punjab are free from hailstorms and are suitable for growing temperate fruits.

Zones of Maharashtra

- Warm Costal Region: 80” to 200” rain, humid
- Western Deccan Region: 30” to 50” rain, partly dry & humid
- Eastern Deccan Region: 15” to 25” rain, fairly dry & hot
- Western Vidharbha & Eastern Marathwada: 20” to 30” rain, fairly hot
- North Eastern Region of Vidharbha: 30” to 40” rain, hot & dry





Climatic requirements for important fruits of India

Mango	**:**	Tropical and sub tropical.
Citrus	**:**	Subtropical but can be grown under temperate conditions.
Grapes	**:**	Temperate but can be grown under subtropical and tropical conditions.
Peaches	**:**	Temperate but low chilling varieties can be grown under subtropical conditions.
Sapota	**:**	Tropical but can be grown under subtropical conditions which are free from frost.
Papaya	**:**	Tropical and mild subtropical climate.
Banana	**:**	Tropical, can be grown under subtropical climate provided it is free from hot winds and frost.
Almond	**:**	Temperate but some low chilling varieties can be grown under subtropical climate.
Apple	**:**	Temperate but low chilling varieties can also be grown on lower hills.

RESEARCH ORGANISATIONS IN HORTICULTURE

1. Indian Institute of Horticultural Research (IIHR), Bangalore
2. Indian Institute of Vegetable Research (IIVR), Varanashi
3. Indian Institute of Spices Research (IISR), Calicut, Kerala
4. Central Institute of sub-tropical Horticulture (CISH), Lucknow
5. Central Institute of Temperate Horticulture (CITH), Srinagar
6. Central Potato Research Institute (CPRI), Kufri, Shimla
7. Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala
8. Central Plantation Crops Research Institute (CPCRI) Kasargod, Kerala
9. Central Institute of Arid Horticulture (CIAH), Bikaner, Rajasthan
10. Central Institute of Post Harvest Engineering and Technology (CIPHET), Ferozepur, Punjab
11. ICAR Research Complex for Goa, Ela, Old Goa
12. ICAR Research Complex for North Eastern Hill Region. Barapani, Meghalaya
13. National Research Centre for Banana. Trichirapalli, Tamil Nadu
14. National Research Centre for Citrus, Nagpur, Maharastra
15. National Research Centre for Onion and Garlic, Pune, Maharastra
16. National Research Centre for Grape, Pune, Maharastra
17. National Research Centre for Medicinal and Aromatic Plants, Anand, Gujarat
18. National Research Centre for Mushroom, Solan
19. National Research Centre for Orchid, Gangtok, Sikkim
20. National Research Centre for Cashew nut, Puttur, Karnataka
21. National Research Centre for Seed Spices, Ajmer, Rajasthan
22. National Research Centre for Oil Palm, Eluru, Andhra Pradesh
23. National Research Centre for Pomegranate, Solapur, Maharastra
24. National Research Centre for Makhana, Patna, Bihar
25. National Research Centre for Litchi, Muzaffarpur, Bihar
26. National Horticulture Board (NHB), Gurgaon, Haryana

CLASSIFICATION OF HORTICULTURAL PLANTS

- India is endowed with rich vegetation wealth with rich diversity of plant wealth.
- About 9,500 species of ethno botanical interest have been recorded.
- Out of these, more than 50 types of fruits and vegetables, many individual types of spices, plantation crops etc. are under commercial cultivation in different parts of the country, under different sets of growing conditions.
- An attempt to deal with all these plants separately becomes tedious, cumbersome and infeasible and more so repetitive.
- To avoid these difficulties, it is better to classify the plants in groups, based on similarity or dissimilarity of attributes.
- Plants having similarity in either of the traits are placed under one group. Such type of grouping plants in different categories is referred to as classification.
- The overall objective of the classification is to systematize the presentation and make the remembrances of the plants easy and convenient.
- Generally based on botanical relationship, the plants are classified.

Different group of plants are classified based on the following criteria:

I. FRUITS:	II. VEGETABLES	III. FLOWERS
1. Based on nature of growth 2. Based on climatic requirement 3. Based on continuation of growth 4. Based on types of fruit 5. Based on parts used 6. Based on botanical relationship 7. Based on salinity tolerance 8. Based on ripening behaviour 9. Based on ethylene evolution 10. Based on bearing habits 11. Based on photoperiodic requirement	1. Based on botanical relationship 2. Based on hardness or temperature tolerance 3. Based on tolerance to soil acidity 4. Based on tolerance to salt 5. Based on parts used as food 6. Based on methods of raising 7. Based on forcing 8. Based on rate of respiration 9. Based on pigmentation	1. Based on season of growing 2. Based on colour of flower 3. Based on purpose of growing 4. Based on nature of growth 5. Based on mode of propagation 6. Based on growth behaviour 7. Based on photoperiodic requirement 8. Based on ability to grow
IV. SPICES 1. Based on completion of life cycle 2. Based on growth behaviour 3. Based on importance →	4. Based on part used 5. Based on utility 6. Based on cultural management 7. Based on botanical relationship 8. Based on photoperiodic requirement	**V. PLANTATION CROPS** 1. Based on botanical relationship 2. Based on growth behaviour 3. Based on utility 4. Based on extent of growing 5. Based on intensity of cultivation

Influence of environmental factors on horticultural crop production

Temperature: It is an important determinant of plant growth. High as well as low temperatures influence the growth of plants. Broad leaved, ever green plants are very much susceptible to low temperature. Fall of temperature below $5^{O}C$ put a strain on the survival of such plants. Deciduous plants by their adoptive mechanism to shed foliage are better able to tolerate low temperature. Such plants pass their lives in dormant stage during winter. Generally, a temperature range of 20 - $30^{O}C$ is considered ideal for majority of tropical and subtropical plants. Temperate plants require chilling winter. In majority of temperate fruit plants, flowering commences subject to fulfillment of chilling temperature ranging from $2^{O}C$ to $7^{O}C$. High temperature above $40^{O}C$ causes scorching in plants. The leaves show burning symptom along tip and margin. High temperature causes bolting and seed formation in spinach and lettuce. Development of red colour in oranges is governed by low temperature. More severe winter favours discontinued synthesis of chlorophyll and unmasking of carotenoids which imparts red colour to oranges. The optimum temperature for most of the plants varies in the range of $22^{O}C$ to $27^{O}C$. High fluctuation in day and night temperature badly influences the growth and production of plants.

Humidity: It is a crucial component of climate affecting growth and production of crop. Humidity is essential for growth of the plants and qualitative development of the fruits. The kharif plants and vegetables grow fast with abundant humidity during monsoon season. The colour, TSS (total soluble solids), sugar and acid blend is bettering in dry atmosphere having very little humidity. The oranges grown under high humidity have thin rind and more juice. Low humidity favours better colour development in oranges. High humidity favours resurgence of diseases and pets also. High humidity during March causes powdery mildew disease in mango. Fruit fly incidence is more in mango if there is high humidity in atmosphere at the time of fruit ripening. Fluctuation in atmosphere humidity is the main attribute behind cracking of fruits. Under less humid conditions the fruit skin is smooth, thin and shiny and it is important where the fruit skin is edible like Guava, Ber, apple etc.

Wind: High velocity and hot winds cause heavy damage to fruit trees. They cause breakage of limbs of fruit trees. High velocity winds also cause shedding of flowers and dropping of fruits. Dry winds bring scorching and torning impact on the leaves of banana. The increasing wind velocity retards the activity of pollinators. Bee activity is maximum when wind is still, gets little reduced when wind is 2-3 km per hour, gets greatly reduced when wind velocity is 25 km per hour and their activity is altogether ceased when the wind velocity is 40 km per hour. In wind storm, spray of pesticide and other chemicals become difficult. For successful cultivation of fruit crops, raising of dense windbreak rows around the orchard is necessary. The trees like eucalyptus. shisham, casuarina, seedling mango, and jamun may be used as wind breaks.

Rainfall: The amount and distribution of rainfall is important factors in growth and development of crop. Rain at the time of flowering washes out pollen grains and greatly reduces the fruit set. A year of normal rainfall creates conducive condition and yields better growth and harvest of plant. The fruits like guava, pomegranate, ber and sapota in which flowering synchronizes to rainy season, normal rainfall brings bumper harvest. Water is required at different stages of plant growth. Water shortage at the time of early growth, bud differentiation, blossoming, and fruit set and development results in undesirable effect. Rains before harvesting cause softening of fruits in banana and date palm and induce infection of fruit fly in guava and peaches. It is generally observed that fruits are more juicy where they mature during rainy season due to high atmospheric humidity. Fruits that mature during rainy season contain less sugar and more acid than fruits maturing during dry season. Keeping quality of fruits and vegetables developing under high atmospheric conditions may not be good.

Hailstorms: These causes great damage to the fruit crops. Occurrence of hail at the time of flowering and fruit maturity is very disastrous because flower and fruit drop is heavy and the growers get poor returns for their produce. For successful cultivation of fruit crops, only those areas where hailstorms don‘t occur should be selected.

Solar radiation: It is the primary source of energy to plants. For the transformation of light energy to chemical energy leading the production of photosynthates, solar radiation is must. Orchard, located on southern side of the slope receiving better amount of radiation, bears better yield than other side. The periphery and top most portions of plants are more productive due to better and direct absorption of solar radiation. Training and pruning of plants are maneuvered in a way; so that the plant may be better able to absorb more solar radiation required for good productivity.

Classification of plants according to photoperiodic requirements.

1.	Short-day plants	Strawberry, Chrysanthemum, *Cosmos bipinnatus*, Aster, Poinsettia, *Impetiens balsamina* (Balsam), *Salvia occidentalis, Euphorbia pulcherrima, Xanthium pensylxanicum,* Rice, Some soyabean varieties and Tobacco.
2	Long-day plants	Spinach, Beet, Radish, Potato, *Hibiscus syriacus*, *Hyoscyamus niger, Anethum graveolens* (Dill), *Plantago* lanceolata and Wheat.
3	Day-neutral plants	Most of the fruit crops, Tomato, Pepper, Cucumber, *Mirabilis* (Four O Clock plant), Cotton, Certain varieties of peas, Buck wheat and Snapdragon.
4	SL plants	Strawberry, *Primula malacoides* and *Cineraria hybrid.*
5	LL plants	*Chrysanthemum leucanthemum, Silene pendula.*
6	LS plants	*Physostegia verginiana, Bottonia latisquama.*
7	SS plants	*Pharbitis nil, Cosmos bipinnatus and Glycine max.*
8	LI plants	*Phlox paniculata.*
9	SI plants	Late varieties of rice.
10	IS plants	*Chrysanthemum articum.*
11	IL plants	Spinach and Wheat
12	II plants	*Capsicum frutenscens* (Bell Pepper) and Early varieties of rice.

SOIL: Soil is the upper most crust of earth surface which supports plant growth. It is defined as a three phase system in which plants grow. These phases are solid, liquid and gas and are essential. Solid part is frame which provides space for other two. This consists of minerals, clay minerals and organic matter. The soil is also a living system with millions of microbes that breakdown organic matter and builds it again. Microbes are essential and survive only when soil is well aerated and rich in organic matter and devoid of waterlogged conditions. Texture of soil depends on the size of solid particles and classified as gravel, coarse and fine sand, silt and clay. Soils are classified according to relative distribution of these particles and there are 12 textural classes. Likewise, arrangement of these particles is referred as structure, and both texture and structure lend soil physical properties like water holding capacity, aeration and bulk density. Generally loamy soils and crumb structure are most preferred for fruit crops. According to level of organic matter, soils are classified as mineral soil or organic soil and soil having more than 20% organic matter is organic soil like peat and muck. Minerals and salts lend chemical properties to the soil like pH, alkalinity, sodicity, salinity

and cation exchange capacity which influence the availability of nutrients in soil. Therefore, for making choice for soil, soil analysis in terms of following criteria is essential to decide on land capability.

Criteria for land capability class:

i. Slope and erosion hazard.
ii. Soil depth.
iii. Drainage.
iv. Workability.
v. Stoniness and rockiness.
vi. Water holding capacity.
vii. Permeability.
viii. Nutrient availability.
ix. Fertility status.
x. Salinity, alkalinity and acidity hazards.

Based on these criteria there are 8 capability classes, of which (i) to (iv) are suitable for cultivation and (v) to (viii) are not suitable for cultivation. The soil provides support for the plant and act as storehouse of nutrients and water as well as oxygen for root growth. The ability of the soil to support plant growth is often referred to as its productive capacity which depends on fertility and physical condition. Therefore, the soil has to be a good soil. A good soil is one which has the capacity to nourish and sustain plant growth by providing mineral particles (nutrients) in an available form to plants by their interaction with soil air, moisture, microbes and humus.

Generally a loam soil is considered to be a good soil. Generally fruit crops need porous, aerated, deep (2 m) uniformly textured soils and the pH of soil should be within range of 6-8. Soil with hardpan within 120 cm from surface, soil with high clay content at surface and very less at subsurface or vice-versa are not suitable for fruit crops. Fruit crops are susceptible to waterlogged condition and growth is adversely affected by salinity, sodicity and alkalinity. It is, therefore, important that soil be analyzed for its quality and then choice of the crop is made for sustainable production. If the soils are problematic like poor aeration or drainage, sodicity, alkalinity, acidity and salinity, they require improvement or reclamation before taking up crop production or the venture would fail. Alternatively tolerant or resistant crops can be choosen for different problems.

Salinity tolerant crops: Kair, Khirni, Woodapple, Date palm, Ber, Aonla, Fig, Sapota etc.

Sodicity tolerant crops: Ber, Tamarind, Woodapple, Date palm, Aonla, Karonda, Fig, Phalsa, Pomegranate, Guava, Bael and almond.

Drought tolerant crops: Ber, Aonla, Ahalsa, Lasoda, Kair, Custard apple, Karonda, Fig, Guava etc.

If we know the soil and the requirement of soil for the crops, then choice of the crop can easily be made.

Grouping of fruits according to their tolerance to salinity:

a. **High salt tolerance :** Date palm, Ber and Aonla.
b. **Medium salt tolerance :** Pomegranate, Fig and Grape.
c. **Low salt tolerance :** Apple, Orange, Almond, Lemon and Avocado.

In making choice of soil for fruit crops physical properties should he emphasized, more as chemicals can be added from outside to improve nutrient status and chemical properties of the soil. Generally the depth and the drainage-ability are very important for crop production. To upkeep soils for sustainable production following things are to be done before and after planting a crop:

Soil analysis in terms of its physical and chemical attributes

- Bring the soil to its optimum potential by applying organic matter, chemical fertilizers, micronutrient and amendments depending on soil analysis report.
- Adoption of soil conservation technique like green manuring on regular basis.
- Use of improved water management techniques like drip irrigation and check basin or Furrows.
- Incorporation of large quantity of bulky organic matter each year.
- Creation of appropriate drainage around the plot.
- Scrapping of salts and reclamation of soil by application of gypsum, iron pyrites, press mud etc., on regular basis in case of salinity problem.
- Replenishment of nutrients harvested by the crop on regular basis by preparing a balance sheet for nutrients.
- Recycling of organic waste.
- ***Soil is the most important natural resource for fruit culture and it needs to be protected and improved.***

Propagation of Horticultural plants

Nursery: Nursery is a place where seedling, saplings or any other planting materials are raised, propagated, multiplied and sold out for planting.

Importance of Nursery:

1. The young seedlings require special attention during the first few weeks after germination. It is easier and economical to look after the young and tender seedlings growing in nursery bed in a small area than in a large permanent site.
2. Majority of fruit crops are propagated by vegetative means. The propagules require special skill and aftercare before transferring them in the main field. In a controlled condition in nursery all these can be provided successfully by skilled labour.
3. Cuttings are best rooted and grafts are hardened in the mist house chamber which is an integrated part of a nursery.
4. Direct sowing method is not so successful in several crops when compared with transplanting of seedlings raised in nursery.
5. Plants hardened in the nursery are preferred for causality replacement in orchards.
6. Besides these, raising of seedlings or saplings in nursery provides more time for pre-planting operations/ preparations.
7. Seasoning/hardening of seedlings against natural odds is only possible in nursery.

Classification of nursery: Nursery can be broadly grouped into two on the basis of its site:

1. **Home nursery:** is the area where planting materials specifically grown or raised only to cater the needs of the growers garden.
2. **Commercial nursery:** Nurseries are larger in size and collection of plants. This is mainly concerned with economic returns from the investments

Factors affecting the establishment of a nursery:

Location and site- Topography, climate	Water facility
Reputation of locality for business and transport facility	Manures
Selection of soil	Availability of labour

Components of nursery: A nursery should consist of the following components:

1. **Building structures:** This includes office, sale counter, packing shed, potting shed, store, implement shed and residential quarter.
2. **Progeny tree block:** The current choice of kind and variety of fruit crops and collection of true to type mother plants have strong bearing on the success and goodwill of a nursery industry.
3. **Propagation structures:** structures like green house, glass house, poly house, hot bed, cold frames, lath house, shade house, mist house are used to create congenial condition for the propagation of plants.
4. **Nursery bed.**

Plant propagation refers to the multiplication of an individual plant or group of plants, which have specific value to mankind. Perpetuation of plants is called propagation. It involves multiplication of one plant into several plants –development of new individuals. New plants or new individuals are required for establishing **new plantings / new gardens/ new orchards**.

Methods of propagation: Broadly grouped in to two. (a) **Sexual** and (b) **asexual.**

Sexual (Seed) Propagation: It refers to multiplication of plants by seed. In sexual process male and female gametes are fused to produce seed. Meiosis division takes place in course of fusion and the chromosome numbers, as in parents is reduced to half, which after fertilization becomes normal. In sexual propagation during meiosis segregation, reassortment or rearrangement of characters takes place. So, the plants thus produced may or may not be similar to their parents and the propagated plants may also be different from

each other**.** It is called as seed propagation, since the propagation is through seed and also sexual propagation because sexes are involved **Seed** is the result of fusion of male and female gametes. Seeds are fertilized ovules, containing embryos resulting from the union of a male and a female gamete during fertilization. The embryo in the seed gives rise to a new plant on germination. Plants that are produced from seeds are called **seedlings.**

Advantages of Seed propagation: 1) Seedling trees generally live longer, bear more heavily and are hardier than vegetatively propagated trees. 2) Seedlings are comparatively cheap, and can be more easily raised than vegetatively propagated materials. 3) Plants which are difficult to propagate, e.g., papaya and phalsa by vegetative method can only be propagated by seed. 4) In breeding for evolution of new varieties, the hybrids are first raised from the seed and it is, therefore, essential to employ this method in such cases. 5) Seed propagation, some times results in the production of **Chance seedlings** with superior characteristics, which may be of great benefit to the horticulture industry. 6) Rootstocks, on which desirable scion variety is budded or grafted, are usually raised from seeds. 7) Seeds of some fruits like citrus and mango varieties are capable of giving out more than one seedling from one seed. They arise from the cells of the nucellus and are called poyembyonic. The nucellar seedlings can be utilized for raising uniform plants, if they can be carefully detected at the nursery stage. 8) Since most virus diseases are usually not transmitted through seed propagation. Hence, it is useful in producing virus free plants. 9) Seeds also offer a convenient method for storing plants for a long time. Seeds when kept properly may remain viable for very long periods. Eg. Indian lotus remains viable for over 1000 years.

Disadvantages of seed propagation: 1) Owing to genetic segregation in heterozygous plants, seedling trees are not uniform in their growth, yielding capacity and fruit quality compared with asexually propagated plants. Seedling trees are not usually true to type and show variation. 2) Seedling trees take more time to come to bearing than grafted plants. For example mango seedlings take 8 -10 years to come to bearing, compared with 3-4 years for grafted trees. 3) Seedling trees, being very large, pose problems for efficient management of orchard trees, i.e., harvesting, pruning spraying etc. become more difficult and expensive.

4) It is not possible to derive the benefits of rootstocks, if the plant is not propagated vegetatively by means of grafting or budding. 5) Continuous seed propagation leads to inferiority in the progeny. 6) Sexually propagated plants have long juvenile (pre-bearing) period. 7) Choice or chance tress or hybrid trees can not be multiplied true to type because of segregation of characters. 8) Seeds loose viability with in a short period.Eg.Citrus, mango, jack, papaya, jamun etc.

Seed Dormancy

- Time of development to germination - Inactive stage of embryo
- Failure of viable embryo to germinate is called dormancy
- External Dormancy: lack of moisture, High Temp, Oxygen
- Internal Dormancy:
  - Condition within embryo (Embryo Dormancy)
  - Influence of Hard Seed coat (Seed coat Dormancy)
  - Substances in seed or fruit chemically inhibit (Inhibitory Dormancy)

Embryo Dormancy

- Freshly harvested seed required some period of dry storage before germination
- Change in storage is called ***After ripening***, after certain period of rest, seed can be used.

Seed coat Dormancy

- Impermeability of seed coat to water
- Decomposition of seed coat: moisture & warm temperature
- Supply of Nitrates effects seed coat softening
- Membranous seed coat layer restrict transfer of gas

Inhibiteroy Dormancy

- Small portion of endosperm in contact with embryo prevents germination

Pre germination treatment to break the dormancy

- Soaking: Soaking period depends on hardness of seed coat (Guava)
- Scalding: immersed in Hot boiling water and allowed to soak in the gradually cooling water for 12-24 hrs
- Mechanical: Rubbing the seeds in folds of sand paper (Chiku, Canna & Ber)
- Stratification: Alternate layers of soil & moist sand at 32 ^{o}F to 45 ^{o}F for 1 to 4 months (Apple, Pear & Cheery)
- Scarification (Chemical): 25 to 50 % H_2SO_4 treatment is given to seed

Seed Sowing

- Seeds are sown in raised beds, pots, poly bags, etc
- Soil solarisation is done. Adding FYM + Sand, Ideal potting mixture is developed.
- Seeds are sown 7 mm to 1.25 cm deep in rows 10 cm apart
- Normally seed requires 3 to 4 weeks for germination in majority of crops.

Asexual propagation: It is called with different names -- Asexual propagation, Vegetative propagation, Clonal propagation. Asexual propagation is reproduction by means of vegetative parts of the plant such as roots, shoots, or leaves other than seed. In this propagation sexes are not involved–hence it is called **asexual propagation**. It involves the use of any part of the plant, other than seed i.e. vegetative parts –hence **vegetative propagation**. The vegetative organs of many plants have the capacity (ability) for regeneration, to produce new individuals. For instance: (a) stem pieces (cuttings) produce root system (b) Root pieces (root cuttings) develop root system. (c) Leaves generate both roots and shoots. Vegetative parts possess somatic cells. They divide (multiply) by mitosis –does not involve reduction in chromosomal number, but involves the duplication of chromosome structure -the same genetic constitution is seen in the resultant plants – no variation. Whatever the characters present in the parent –the same are carried in the new plants i.e. duplicated without any change –true to mother plant-variation is eliminated. **Advantages:** 1) There are many horticultural plants that normally produce little or no viable seeds. Common examples of such plants are some varieties of banana, pineapple, fig, orange, grape, rose, and gardenia. The edible seedless fruits are certainly very important economic crops but, unless they can be propagated by vegetative means, perpetuation of these plants is not possible and these will be lost in no time. 2) Most of our choicest fruits such as mango, citrus, apple, peach etc. are crosspollinated plants and naturally are highly heterozygous. Such cross pollinated plants are not true to type and loose many of their unique characteristics when raised from seeds. For example, seedling mango varieties like the langra or dasheri bear fruits quite unlike those of parent plants. The fruits vary greatly in size, shape, colour, quality, maturity period, keeping quality, chemical composition and other Characteristics. In contrast the trees raised by vegetative means (grafting) bears fruits just like those of the tree from which the scion has been collected. Hence, asexual propagation helps in maintaining the characteristics of each cultivar. 3) Propagation by vegetative means is sometimes easier, more rapid and economical than that by seeds. In some species the germination is very poor or slow or there may exist complex dormancy problems (Peach and Olive) or the seed may lose its viability very quickly (mango, Litchi, Citrus). Moreover, seedlings of many species grow slowly and take a long time to reach salable size (Date palm, Litchi). In all these cases, use of vegetative means is more convenient method of propagation. 4) It often happens that certain species or varieties (which are otherwise desirable) are susceptible to some insects or diseases, where as others may be largely or entirely resistant. The root system of European grapes (*Vitis vinifera*) is susceptible to insect **phylloxera**, but the American species (*Vitis americana*) is fully resistant to the attack of this insect. Thus by growing European grapes on American stock, this deadly insect can be easily eliminated. Likewise trifoliate orange when used as a root stock of sweet oranges, which is susceptible to **gummosis**, imparts resistance against this disease. 5) Budding or grafting may be used to make certain fruits adaptable in unfavorable environmental conditions. Frequently, certain root stocks are better adapted to the environment than the roots of the variety desired or other rootstocks. For instance trifoliate oranges are much better adapted to severe winter freeze than other rootstocks. Similarly Rangapur lime is more salt tolerant than other citrus rootstocks. 6) Vegetatively

propagated plants are usually less vigorous than seed propagated ones. Moreover, by using certain rootstocks (vigorous, semi dwarf or dwarf), the size of a tree can be controlled greatly. For instance apple on **Malling IX**, pear on **quince** root stock are noticeably dwarf, and as a result many orchard operations such as pruning, spraying and harvesting can be done more easily, conveniently and cheaply 7) Vegetatively propagated plants are more precocious in bearing (flower earlier than seed propagated plants). Pre-bearing period is less. No juvenility. For example, seed propagated mango plants take at least 8-10 years to flower, where as grafts flower within 3-4 years. 8) Another use of vegetative propagation is found in fruit plants, which are self-incompatible. Instead of planting occasional variety suitable for pollination, a single branch of the pollinizer variety may be grafted on to the main variety. A composite plant bearing fruits of different varieties can be developed by grafting the varieties upon a rootstock. Similarly, an inferior variety can be made into a choicest one by means of top working, when a desired scion is grafted to the existing stock. 9) Plants are propagated asexually to perpetuate a particular form of the plant, for example, citrus trees are normally thorny, especially in the juvenile stage, but when buds are collected from the thorn less portions of mature plants and are used for propagation, the size of the thorns is greatly reduced in the resulting budded plants. Similarly ornamental plants having a particular growth habit (upright or horizontal, drooping or weeping) or unusual form of leaves or flowers are propagated vegetatively to maintain its particular desirable form. 10) Certain injuries can be repaired by means of bridge grafting. **Dis-advantages:** 1) No, new variety can be evolved by means of the vegetative method of propagation. 2) Vegetative propagation in many cases is more expensive than seed propagation. 3) Vegetatively propagated plants are comparatively short lived. Lack of tap root system in vegetatively propagated plants results in poor anchorage in the soil. Consequently, such plants are easily uprooted in storms and or other such severe conditions. 4) Vegetatively propagated plants are comparatively less hardy. 5) Transmit viral diseases from plant to plant.

Which method of propagation is the best? Considering the merits and demerits of both the methods, particularly in fruit crops and other perennial crops, vegetative propagation is more preferable than seed propagation because of uniformity (even in delicate characters like shape, taste, flavour etc.) and precocity.

Plant Propagation by Separation and Division Many herbaceous species that die back at the end of the growing season have underground food storage organs that survive the dormant winter period. These organs are also vegetative propagation structures that produce new shoots in the growing season. The variety of underground storage organs may be grouped into two classes based on how they are propagated; plants propagated by separation and plants propagated by division.

Plants propagated by separation: Separation is a method of propagation in which underground structures of plants are divided not by cutting but by breaking along natural lines between segments. Separation is breaking away of daughter structures from the parent structure to be used to establish new plants. Two specialized underground structures-bulbs and corms-produce such materials.

Bulb: A bulb is a specialized underground organ that consists predominantly of fleshy leaf scales growing on a stem tissue (basal plate).The scales wrap around a growing point or primordium to form a tight ball. Lateral bulblets, or miniature bulbs, originate in the axils of some of these scales and when developed (offsets) may be separated from the mother bulb to be planted independently as new plants. There are two types of bulbs-***Tunicate*** and ***non-tunicate bulbs***.

Tunicate-These bulbs have outer bulb scales that are dry and membranous. This covering called tunic, provide protection from drying and mechanical injury to the bulb. The fleshy scales are in continuous, concentric layers, called lamina, so that the structure is more or less solid. E.g. Onion, daffodil, tulip etc.

Non-tunicate (scaly) bulbs: These bulbs don‘t possess the enveloping dry covering. The scales are separate and attached to the basal plate. The scales are not tight but loose and can be removed individually from the bulb. In general, the non-tunicate bulbs are easily damaged and must be handled more carefully than tunicate bulbs. The daughter bulbs or bulb lets develop at the base of the of the scales of the mother bulb. Eg. Lily.

Corm: The bulb consists predominantly of modified leaves; the corm is a modified stem. Food is stored in this compact stem, which has nodes and very short internodes and is wrapped up in dry, scaly leaves. When a corm sprouts into a new shoot, the old corm becomes exhausted of its stored food and is destroyed as a new

corm forms above it. Several small corms, or cormels, arise at the base of the new corm. The cormels may be separated from the mother corm at maturity (die back) and used to propagate new plants. Eg. Amorphophallus, Colocasia, Gladiolus etc.

Plant propagation by division: It is a method of propagation of plants using cut section of a particular part like rhizome, tuber and tuberous root etc.

Rhizome: A rhizome is a specialized stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground. The stem appears segmented because it composed of nodes and internodes. The rhizome appears as a many branched clump made up of short individual sections. The rhizome tends to be oriented horizontally with roots arising from the lower side. In propagating plants by rhizome by cutting the rhizome into different sections being sure that each section has at least one lateral bud or eye. It is essentially a stem cutting. Eg. Bamboo, Banana, Iris etc.

Stolon: It is a term used to describe various types of horizontally growing stems that produce adventious roots when come in contact with the soil. These may be prostate or sprawling stems growing above ground. In propagating plants by stolon, the stolon can be treated as a naturally occurring rooted layer and can be cut from the parent plant and planted separately. Eg. Mint, Bermuda grass etc.

Runner: A runner is a specialized stem that develops from the axil of a leaf at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes. In propagating plants by runners, the rooted daughter plants are dug when they have become well rooted and transplanted to the desired locations. Eg. Strawberry, oxalis, blue berry etc.

Stem tuber: A tuber is specialized swollen underground stem which possesses eyes in regular order over the surface. The eyes represent the nodes of the tuber. The arrangement of the nodes is spiral, beginning with the terminal bud on the stolon to produce a new plant, the tuber is divided into sections so that each section has a good amount of stored food and a bud or eye. Propagation by tubers can be done either by planting the tubers whole or by cutting them into section, each containing a bud or eye. Eg. Potato.

Tuberous roots: These are thickened tuberous growth that functions as storage organs. These differ from the true stem tuber, in that they lack nodes and internodes. Buds are present only at the crown or stem end. Fibrous roots are commonly produced towards the opposite end. Most plants with fleshy roots must be propagated by dividing the crown so that each section bears a shoot bud. Eg. Dahlia, Begonia, Sweet potato

Offset: It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. These are special type of branches or lateral shoots which are produced from the base of main stem of parent plant. The offset often breaks away from the mother plant and the daughter starts a new independent life. Eg. Pistia, Agave, Water hyacinth, Cycas, Dracaena etc

Suckers: It is a lateral branch developing from the underground parts of the stem or roots. The suckers arise from below the surface of the soil. There are two types of suckers.

a) ***Shoot suckers:*** These will arise from the base of the stem. The suckers may grow obliquely upwards and directly give raise a leaf shoot. Often it grows horizontally outwards only to certain extent but soon turn up. It strikes roots when it is still attached to the parent plant or when separated and planted. Propagation by shoot suckers can be done by separating the suckers and planting. Eg. Chrysanthemum, Banana, Pineapple, Yucca b) ***Root suckers:*** The root suckers will arise from the adventitious buds on the roots. Propagation by shoot suckers can be done by separating the suckers and planting. Eg.Guava, Millingtonia, Curry leaf,Quis quails etc

The process of propagation of plants by cuttings is known as cuttage. A cutting is a part of a plant that will produce roots when put in soil media and eventually produce a new plant quite true to the parent plant. A cutting may be a piece of stem, a leaf or part of a leaf, a piece of root, or root stock, or even a scale of bulb.

Classification of cuttings:

Cuttings are usually classified in to 3 groups according to the particular part of the plant used as cutting.

1) Stem cuttings 2) Root cuttings 3) Leaf cuttings

Stem cutting: Stem cuttings can be divided in to 4 types based on the degree of maturity and lignification of wood used in making cuttings. Hard wood stem cuttings, Semi hard wood stems cuttings, Soft wood stem cuttings, Herbaceous stem cuttings

Hard wood stem cuttings: These cuttings are made from the past seasons growth or wood that has matured and lignified are known as hardwood cuttings.

Preparation and planting: Select a fully matured shoot with normal internodes from a healthy, vigorous plant growing in full sun light. Remove all the leaves without damaging the axillary buds. Give a slant cut just below the basal node of the selected shoot. Measure the required length (about 15 to 25cm and containing 3 to 4 buds) from the base of the shoot and give a horizontal cut 1 to 2.5cm above the top node.

Repeat the procedure and prepare as many cuttings as possible from the shoot. In case of difficult to root species treat the prepared cuttings with recommended growth regulators to induce rooting. Make holes in the prepared bed or pot with the help of a stick or dibbler. Insert the cuttings in the hole such that at least two nodes are inside the soil. Take care of polarity while planting cuttings. After planting press the medium firmly around the cutting and water immediately. **Eg:** Grape, Fig, Pomegranate, Bougainvillea, Acalypha, Rose etc.

Hard wood cuttings may be of three types: **Straight or simple cutting**, **heel cutting** and **mallet cutting.**

Straight or simple cutting: It consists of only the current year‘s wood and doesn‘t bear any older wood. Eg. Hibiscus, nerium

Heel cutting: *A* small piece of older wood is retained at the base of each cutting Eg. Rose

Mallet cutting: An entire section of the older wood is retained. Eg. Thuja.

Semi-hard wood stem cuttings: Semi hard wood cuttings are prepared from new shoots just after a flush of growth which is partially matured.

Preparation and planting: Select partially matured shoots from a healthy and vigorous growing plant and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Remove all the leaves towards the base of the shoot and retain only the terminal leaves. If the retained leaves are very large, reduce their size by cutting the top half portion. This facilitates planting the cuttings closer and also minimizes the loss of water from cutting. Plant the cuttings in the same way as hard wood cuttings are planted. Eg. Camellia, Citrus, Eranthemum, Acalypha, Geranium, Hibiscus, Jasmine, Lemon, olive etc

Soft wood cuttings: Cuttings are prepared from the soft succulent new spring growth of species which are 4 to 6 months old.

Preparation and planting: Select the soft succulent shoots from a healthy and vigorous growing plant, growing in full sun light and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Don‘t remove the leaves except for the part to be buried inside the rooting media. Soft wood cuttings should be kept in green house or in moist chamber where a high humidity can be maintained which keeps the tissues in turgid condition. Plant the cuttings in the same way as hard wood cuttings are planted. Eg. Nerium, crotons, Eranthemum, Graftophyllum etc

Herbaceous stem cuttings: This type of cuttings is taken from succulent herbaceous green house plants.

Preparation and planting: Select the succulent herbaceous shoots from a healthy and vigorous green house growing plant. Retain all the leaves. Give a basal cut below a basal node. Plant the cuttings in the same way as hard wood cuttings are planted. *Eg.* Chrysanthemum, Coleus, Carnations, Geraniums, Cactus etc.

Leaf Cuttings: Certain plants with thick and fleshy leaves have the capacity to produce plantlets on their leaves. In leaf cuttings, the leaf blade with or without petiole and axillary bud is used for starting new plants**.** Adventious roots and shoots form at the base of the leaf and form in to a new plant. However, the original leaf does not become a part of the new plant. Frequent watering and high humidity and bottom heating are desirable for better and rapid rooting of leaf cuttings. Sand or sand and peat moss (1:1) are satisfactory rooting media for leaf cuttings. For leaf cuttings, depending on the species the whole leaf blade, leaf blade sections or the leaf with petiole is used. So, leaf cuttings can be classified in to:

1. Leaf blade cutting 2. Leaf vein cutting / Leaf slashing 3. Leaf margin cutting 4. Leaf bud cutting

Leaf blade/Leaf section cutting: *Preparation and planting:* Select a healthy leaf and Give a slanting cut towards the base of the leaf. Measure a length of about 7 to 10-cm and give a horizontal cut towards the terminal end. Prepare as many cuttings as possible from the selected leaf. Insert up to ¾ of the prepared leaf cuttings in to the medium. Take care of polarity while planting the cuttings. Compress the soil around the leaf cuttings and water immediately. Eg. Sansevieria

Leaf vein cutting/Leaf slashing: *Preparation and planting:* Select a healthy and full mature leaf and detach it from the mother plant. Give cuts to alternate veins closer to the petiole on the lower surface of the leaf. Keep the leaf flat on the medium in such a way that the lower portion comes in contact with the medium. Pin or hold down the leaf in some manner so as to expose the upper surface and to maintain the contact between the cuts on the vein and the rooting medium. Water the cuttings carefully *Eg*. Begonia rex.

Leaf bud cuttings: This cutting consists of a leaf blade, petiole and a short piece of the stem with attached axillary bud. This is practiced in species that are able to initiate roots but not shoots from the detached leaves. In such case the axillary bud at the base of the petiole provides for the essential shoot formation. *Preparation and planting:* Select a healthy and mature shoot with well developed buds and healthy active growing leaves. Separate each leaf along with the axillary bud and a small portion of the stem. Repeat the process until possible numbers of leaf bud cuttings are made. Treat if necessary the cut surface of the prepared cuttings with the recommended root promoting substance to stimulate rapid root formation. Insert the prepared cutting in the rooting medium so that the bud is1.5 to 2.5 cm below the surface. Compress the medium around the cutting and water immediately. Eg. Black berry, Camellia, Lemon, Rhododendron & raspberry etc

Leaf margin cutting: *Preparation and planting:* Select a mature and healthy leaf with the foliar embryos intact. Keep the leaf flat on the rooting medium. If the leaf is folded, just cut along the mid rib, so that the leaf can be kept flat on the medium. Keep some weight on the leaf or partially cover it with soil, so that the margin comes in contact with the medium. Water the cuttings carefully Eg. Bryophyllum.

Root cuttings: Plants which give rise root suckers freely are propagated by root cuttings.

Plant propagation by Layering: Layering is the developing of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached or become a new plant growing on its own roots. A layered stem is known as a layer. Layering includes several forms of ground and aerial layering. When rooting is encouraged on the aerial part of a part of a plant after wounding it is known as air layering or gooty or marcottage. When branches running parallel to ground are utilized, it is known as ground layering, The root formation during layering on a stem is stimulated by various stem treatments like ringing, notching etc, which causes an interruption in the downward translocation of carbohydrates and other growth factors from leaves and growing shoot tips. However, the root formation in layered stems, completely depends upon continuous moisture supply, good aeration and moderate temperature around the rooting zone. Sometimes synthetic growth regulators like IBA, IAA etc, are also treated to layered stem to induce better rooting, as the auxins in layered stem is an important factor for rooting.

Advantages: i. It is an easy method and does not require much care and arrangement like cutting. ii. The mother plant supplies nutrient and other metabolites as it remains attached while rooting. iii. By using a large branch a much larger plant can be obtained in the first instance. iv. Some plants that cannot be satisfactorily started from cuttings can be propagated by layering.

Dis advantages: i. It is a costlier method. ii. It is a slow process iii. Limited number of plants can be propagated iv. Layered plants are generally shallow rooted v. Interference with cultivation vi. Require more individual attention vii. The beneficial effect of root stock cannot be exploited.

Classification of layering:

I. Ground layering: 1) Tip layering 2) Simple layering 3) Trench layering 4) Mound layering or stool layering 5) Compound or serpentine layering **II. Air layering (Gootee or Marcottage)**

Tip layering: It is generally followed in plants which have trailing type of shoots. It is quite similar to simple layering. ***Procedure:*** Dig a hole 3 to 4 inches deep. Insert the tip of a current season‘s shoot and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend.

The re-curved tip becomes a new plant. Remove the tip layer and plant it in late fall or early spring. Examples of plants propagated by tip layering include purple and black raspberries, and trailing blackberries

Simple Layering: In this method, a branch is bent to the ground and some portion of it is covered by soil leaving the terminal end of the branch exposed. Root initiation takes place at the bent and buried portion. After allowing sufficient time for root formation, the rooted stem is separated from the mother plant. Eg. Bougainvillea, Jasmine, Rangoon creeper ***Procedure:*** Select a healthy, flexible and sufficiently long (50 to 60cm) branch towards the base of the plant. The selected branch should be closer to the ground. At a distance of about 15 to 30cm back from the tip give a sharp, slanting inward and upward cut 1.5 to 2.5cm below a node and insert a small wood splinter. Bend the shoot gently to the ground so that the treated part can conveniently be inserted into the soil. Cover the treated region with soil. Peg down the shoot or keep a stone of brick on the covered soil to keep the layered shoot in place. Drive a vertical stake into the soil by the side of the layered branch and tie the terminal portion of the branch to keep it upright. Water the layered portion regularly so as to keep it moist all through till root initiation take place. After sufficient root formation separate the layer by cutting just below the rooted zone.

Compound or serpentine Layering: Compound layering is essentially the same as the simple layering except that the branch is alternatively covered and exposed along its length. The branch for compound layering must be long and flexible so that it can be layered at different places along its length. **Eg.** Bougainvillea, Jasmine, Rangoon creeper ***Procedure:*** Select a healthy, flexible and sufficiently long (100 to 250 cm) basal branch that is close to the ground. Give a sharp slanting, inward and upward cut 1.5 to 2.5 cm below a node at 30cm interval starting from the tip leaving 3 to 3 buds in between two such cuts. Bend the shoot gently to the ground, and insert and cover the cut portions with the soil exposing the uncut portions. The remaining steps are same as in simple layering.

Mound (stool) Layering: In this method, a plant is cut back to the ground level during the dormant season and soil is heaped around the base of the newly developing shoots. After slowing sufficient time for root initiation, individual rooted layers are separated from the mother plant and panted. Eg. Apple roots tocks, Guava, Litchi, Quince ***Procedure:*** Select the plant to be mound layered or plant a rooted layer in a trench and allow it to grow for a year. Cut back the plant to 2.5 cm from the ground level just before growth begins. Allow the new shoots to develop. When these shoots have grown 7 to 15 cm tall, girdle them at the base and treat the girdle portion with the recommended growth regulator and draw up the loose soil round each shoot to half its height. When these shoots have are 20 to 25 cm tall add soil again to half their height. Add soil again when the shoots grow to a height of about 35 to 45 cm. Water the heaped soil regularly and allow sufficient time for the initiation of roots. A depression can be made in the centre of the heap to hold water. After sufficient root formation, remove the heaped soil and cut the rooted shoots individually to their base. Transplant the rooted shots in pots or suitable containers

Trench Layering: Trench layering consists of growing a plant or a branch of a plant in a horizontal position in the base of a trench and filling in soil a round the new shoots as they develop, so that the shoot bases are etiolated. Roots develop from the base of these new shoots. Etiolated roots develop from the base of these new shoots. Trench layering is used primarily for woody species difficult to propagate by mound layering. Trench layering is used primarily for woody species difficult to propagate by mound layering. Eg. Apple rootstocks, Litchi, Quince ***Procedure:*** Dig small trenches of about 25-30cm deep and in about 1 m wide rows. Plant rooted layers or one year old nursery – budded or grafted plants in the trenches in rows at an angle of 30^{O} to 45^{O} and 50 to 10 cm apart within the row. The rows should be1.2 to 1.5 m apart. Just before growth begins, lay the plant or a branch flat on the bottom of the trench. Plants must be kept completely flat with wooden pegs or wire fasteners**.** Cut back the shoots slightly and remove the weak branches. Add roots medium (sand or sawdust or peat moss) or their mixture at intervals to produce etiolating on 5 to 10 cm of the base of the developing shoots. Apply first 2.5 to 5 cm layer before buds swell and repeat as shoots emerge and expand. At the end of the season, remove the medium and cut off the rooted shoots close to the parent plant. Transplant the rooted shoots in pots or suitable containers.

II. Air Layering: In air layering roots form on an aerial shoot. The rooting medium is tied to the shoot for getting root initiation. Sphagnum moss is the best rooting medium for air layering as it holds large quantities of water till root initiation and through the root initiation and through the root development. Eg. Crotons, ficus, fig, Guava, Phalsa, Pomegranate **Procedure:** Select a healthy branch of previous season's growth. At a point 15 to 30 cm back from the tip of the shoot make a girdle just below a node by completely removing a strip of bark 2 to 3.5 cm wide all around the shot. Scrape the exposed surface lightly to remove traces a phloem or cambium to retard healing. In difficult to root species treat the girdled portion with the recommended growth regulator to induce better rooting. Cover the girdled portion with moist propagating medium. Sphagnum moss saw dust, vermiculite. Tie the medium around the girdled portion using a polyethylene sheet. Tying should be perfect so that no water can enter the treated part. After observing the fully developed roots through the transparent polyethylene sheet, separate the root zone and transplant the layer appropriately.

Plant propagation by grafting: Grafting is an art of joining parts of two independent plants in such a manner that they unite and grow together into single independent plant. The part of graft combination which is to become the upper portion or the shoot system or top of the new plant is termed the **scion** or **cion** and the part which is to become the lower portion or the root system is the **rootstock** or **under stock** or some time **stock**. The single plant obtained as a result of union between the stock and scion is termed as **Stion**.

Methods of grafting: Mainly in grafting there are two types. ***Attached scion methods of grafting*** *and* ***detached scion methods of grafting*** In attached scion methods of grafting the scion is still attached to the mother plant (Scion Plant) till the graft union takes place where as in detached scion methods of grafting the scion is separated from the scion plant or mother plant just before grafting. Under attached scion methods of grafting simple inarching or approach grafting is most important.

Simple inarching / Approach grafting: The distinguishing feature of this method of grafting is that two independent plants on their own roots (self sustaining) are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of successful graft. Eg.Guava, mango, Sapota. ***Procedure:*** Select a healthy shoot of having a 3.5cm girth on the selected mother plant which is to be used as a scion source. Select a root stock (raised in pot) having approximately the same size as that of the selected shoot on the mother plant. On the internodal region, where the union is to occur, a slice of bark and wood 2.5 to5 cm long is cut from both the selected stock and scion shoots. The cut should be given on the stock and scion should be of the same size. The cuts should be perfectly smooth so that a close contact of the cambial layers of stock and scion is brought about when they are pressed together.Tie the two cut surfaces together tightly with string or cloth. **Pre-curing of scion:** In detached scion methods of grafting, the scion is to be procured before grafting. For precuring, a partially matured scion shoot about the thickness of a little finger is selected. The maturity is indicated by the presence of dark green leaves and grey dark colour on the shoots. The selected shoot is defoliated retaining only the petioles up to a length of about 4 inch from the apical bud. The defoliated shoot is left on the tree for a period of 7-10 days. During this time, the budon the shoot begins to swell. This shoot is then called as **Pre-cured scion**, which is separated from the tree. In detached scion methods of grafting there are two types-they are ***side grafting*** and ***apical grafting*** methods**.** Among the detached scion methods of grafting the important ones are described below. Under side grafting method Veneer grafting is important and is described below.

A-Prepared root stock, **B**-prepared Scion, C-Scion inserted, **D**-Girdled stock and tied graft joint, **E**-Sucessful graft, the stock being removed

Veneer grafting: This is also a kind of side grafting with slight modification. It is used widely for grafting small potted plants and *insitu* grafting .Eg. .Avocado, Mango etc ***Procedure:*** On the stock plant, at the desired height, in the internodal region, give a shallow inward cut running to a length of about 2.5 to 5cm. At the base of the first cut make another short and inward cut intersecting the first cut and remove a piece of wood and bark. On the scion, towards the base, give a long (2.5-5.0cm), slanting cut towards one side and another short, inward and downward cut on the opposite side. The cuts given on stock and scion should be of

same dimensions, so that, the cambium layers can be matched as closely as possible. Insert the scion on to the rootstock such that a contact of cambium is established at least on one side, and tie them firmly. After the union has healed, cut back the stock above the graft union either on gradual steps or all at once. Among apical detached scion methods of grafting the important ones are described below.

Epicotyl (Stone) Grafting: This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting. Eg. Cashew, mango etc. ***Procedure:*** Select very young seedling about 10 days old raised in polythene bags of size (15cmX22cm). Cut off the top portion of the chosen seedling leaving 5-6cm long shoot (epicotyl).With a sharp knife make a vertical, downward slit (2-3cm long) at the centre of the remaining portion of the epicotyl. Select a dormant 3-4 months old terminal shoot of about 5-8cm long from a proven mother plant as the scion stick. Cut the lower end of the selected scion to a wedge shape by giving slanting and inward cuts of 2-3cm on opposite sides. Insert the wedge shaped scion in the slit made on the seedling and secure firmly with polythene strips or tape. Water the graft regularly without wetting the graft region. In about three weeks the scion starts sprouting. If the seedlings are raised in sand beds they are uprooted (with stones) 15 to 20 days after sowing (when seedlings attain10-15cm height) and grafting is done as described above. The grafted seedling is then planted in polythene bags or pots keeping the graft union above the soil level and without damaging the stone. June to September is the best period for epicotyl grafting.

Soft wood grafting: It has been developed to graft small and young rootstocks which are grown *in situ* or in pots. Eg. Cashew, Mango ***Procedure:*** Raise the rootstock seedlings in suitable containers or preferably in the main field itself where the grafts are desired to be grown and allow them to grow for a year or more. When the seedling attain a height of 30-45cm and the new shoot and leaves usually have bronze colour. Decapitate the top portion of the fresh growth on the stock plant with a knife, retaining bout 8 cm of the fresh stem. Make a longitudinal cut of 3 cm in the retained fresh stem. Select a scion stick of about 10cm long and about the same thickness as of the prepared stem on the stock. Cut the basal end of the scion to a wedge shape of about 3cm long by chopping the bark and a little wood on two opposite sides. Insert the prepared wedge part of the scion stick into the slit made on the stock and secure firmly with polythene strips. Water the grafted plant regularly. The scion sprouts in about three weeks.

Plant Propagation by Budding: Budding is also a method of grafting wherein only one bud with a piece of bark and with or without wood is used as the scion material. It is also called as bud grafting. The plant that grows after union of the stock and bud is known as budding.

T-Budding (Shield budding): This method is known as T-budding as the cuts given on the stock are of the shape of the letter **T**, and shield budding as the bud piece like a shield. This method is widely used for propagating fruit trees and many ornamental plants. This method is generally limited to the stock that is about 0.75 to 2.50cm in diameter and actively growing so that the bark separate readily from the wood. Eg. Citrus, Rose etc. ***Procedure:*** After selecting the stock plant, select an internodal region with smooth bark preferably at a height of 15-25 cm from ground level. Give a vertical cut through the bark to a length of about 2.5-3.75cm. At the top of this vertical cut, give another horizontal cut (1cm or 1/3rd of the circumference of the stem) in such a way that the two cuts given resemble the letter **T.** Lift the bark piece on either side of the vertical cut for the insertion of the bud. Select a required bud stick and start a slicing cut about 1.5cm below the bud and continue it upward and under the bud to about 2.5cm above the bud. Give another horizontal cut about 1cm above the bud. Remove the shield of bark containing bud. The traces of wood, if attached may be removed. Insert the bud between the flaps of bark on the stock with the help of budding knife in such a way that the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud stick tightly with polythene strip exposing only the bud. Successful T budding requires that the scion material have fully-formed, mature, dormant buds and that the rootstock be in a condition of active growth such that the "*bark is slipping*". This means that the vascular cambium is actively growing, and the bark can be peeled easily from the stock piece with little damage.

Inverted T- Budding: In heavy rainfall areas, water running down the stem of the stock may enter the T cut, soak under the bark and prevent healing of the bud piece. Under such conditions an inverted T ( ) budding

may give better results as it is more likely to shed excess water. Inverted T budding procedure is same as that of T budding except the horizontal cut on the stock is made at the bottom of the vertical cut rather than at the top. ***Procedure:*** On the selected stock plant, give a horizontal cut at the bottom of the given vertical cut representing inverted **T.** Select the required bud stick. Start a slicing cut 1.5 cm above the bud and continue it downward and under the bud to about 2.5 cm below the bud. Give another horizontal cut about 1cm below the bud and remove the bud piece. Insert the bud between the flaps of bark on the stock and push upwards till the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud piece and stock completely and tightly exposing only the bud properly.

Patch Budding: In this method a regular patch of bark is completely removed from the stock plant and is replaced with a patch of bark of the same size containing a bud from the desired mother plant. For this method to be successful, the bark of the stock and bud stick should be easily slipping .The diameter of the stock and bud stick should be preferably by about the same (1.5 to 2.75cm) E.g., Ber, Citrus, Cocoa and rubber ***Procedure:*** On the selected stock plant at the desired place (10-15cm above the ground level) give two transverse parallel cuts through the bark and about 1-1.5 cm long or 1/3rd the distance around the stock. The distance between the cuts may be 2-3 cm. Join the two transverse cuts at their ends by two vertical cuts. Remove the patch of bark and keep it in place again until the bark patch with the bud from the selected mother plant is ready. On the bud stick give two transverse cuts-one above and one below the bud-and two vertical cuts on each side of the bud. The dimensions of the transverse and vertical should correspond to those given on the stock. Remove the bark patch with bud by sliding side ways. Cuts with bud by sliding side ways. Insert the bud patch immediately on the stock in such a way that the horizontal cuts of the bark patch and those on the stock plant match together perfectly. Wrap the inserted bud patch with polythene strip covering all the cut surfaces but exposing the bud properly.

Ring budding: The bud is prepared by taking a ring of a bark, 3cm long with the bud in the centre. In the root stock, two transverse cut 1.5cm apart are made and these are connected with a vertical cut and a ring of bark is removed. The prepared scion bud with the ring of bark is fitted in the exposed portion of the rootstock and tied.E.g, Cinchona.

Double working: It is practiced for several purposes (1) to over come incompatibility between the stock and scion.Iincompatible stock and scion may be united by means of a piece of interstock that is compatible to both (2) to secure resistance to drought or cold by providing a disease or cold resistant trunk by means of double working. (3) To obtain resistance to pest and dwarfing effect by using a pest resistant stock and a dwarfing stock and (4) top working of grafted orchard trees is essentially a double working; here the tree trunk as an intermediate stock may exert certain influences on the new top. The inserted intermediate stem piece is called as sinking scion / foster mother /interstock / inter stem.

Top working: Top-working for changing a variety is generally done on long lived species, growing in a healthy condition. Short lived species, old trees or diseased trees are not suitable for top working; in such cases new planting is considered more economical and useful than top working. This practice is resorted to (1) when the existing tree is of inferior type, (2) when the tree is unproductive and (3) to provide pollenizers (4) to change the variety. For top working different methods of grafting like cleft grafting, bark grafting, splice grafting or side grafting can be used. However, cleft is the most popular and commonly used method for top working especially when thick branches are selected. When younger and thin branches are used, whip and tongue grafting are best. Top working of older trees is generally done over a period of two years. In the first year, half of the scaffold branches are top worked retaining the other branches as nurse branches which in turn are grafted in the second year. In the smaller and comparatively younger trees the entire tree is top worked in the first year. Here also one or more nurse branches are retained till the union is successful. Nurse branches protect the top worked scions from winter injury, sun burn and also from desiccating winds and water sprouts develop less frequently when nurse branches are retained. Top working is most successful when relatively young trees are used. If older trees are selected for top working, it is better to select vigorous lateral branches that arise from the main limbs. The branches to be top worked should be cut in such a way that the cut surface is smooth and is at a point of the branch where there are no knots or smaller branches.

Immediately after top working the limbs should be thoroughly covered with grafting wax, sealing all the exposed cut surfaces

CLONAL PROPAGATION: The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. All these plants have the same heredity / genetic constitution and are quite uniform when grown under the same conditions. May be defined as genetically uniform material derived from a single individual parent exclusively by vegetative methods such as cuttings, divisions etc. All the plants of a clone are true to the parent in their growth and performance. The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. The group of plants or horticultural variety derived from one original plant by means of vegetative propagation (e.g. rooting of cuttings or slips, budding, grafting, bulb lets etc) have the same heredity and are quite uniform when grown under the same conditions. Also the vegetative progeny from a single seedling. Clone of many commercial crops like potato, tea, banana, onion, turnip and many horticultural crops have been established by clonal propagation. In many plants which are heterozygous and sterile, clonal propagation is the only means of perpetuation. Clonal selection and propagation can also be used to evolve new varieties in vegetatively propagated plants. The steps involved in the production and maintenance of a clone: There are essentially three steps in the production and maintenance of clone. (1) Selection of pedigree and pathogen free, true to type, stock plants, (2) maintenance of stocks in a disease free condition and rouging of off types and (3) propagation and distribution of such stocks.

MICRO PROPAGATION: Micro propagation (tissue culture or invitro culture) refers to the multiplication of plants, in aseptic condition and in artificial growth medium from plant parts like meristem tip, callus, embryos anthers, axillary buds etc. It is a method by which a true to type and disease free entire plant can be regenerated from a miniature piece of plant in aseptic condition in artificial growing medium rapidly throughout the year.

Merits of micro propagation: a) Tissue culture helps in rapid multiplication of true to type plants throughout the year. b) A new plant can be regenerated from a miniature plant part, whereas, in conventional methods a shoot of considerable length is required. c) Large number of plants can be produced in culture tubes in small space with uniform growth and productivity instead of growing them in large areas in nursery.
d) Plants raised by tissue culture are free from diseases. e) Tissue culture coupled with somatic hybridization (production of hybrid cells by fusion of two protoplasts with different genetic makeup) helps in evolving new cultivars in a short time. f) Micro propagation facilitates long distance transport of propagation materials and long term storage of clonal materials. g) Tissue culture methods are particularly effective in plants that don‘t breed true from seeds, seeds are not viable (male sterile) or not available (banana) and in plant where propagation by conventional methods are expensive (Orchids)

Demerits of Micro propagation: a) The cost involved in setting up and maintenance of a laboratory is very high and may not justify their use in all the horticultural plants ordinarily. b) Tissue culture techniques require skilled manpower. c) Slight infection may damage the entire lot of plants. d) Some genetic modification (mutation) of the plant may develop with some varieties and culture systems, which may alter the quality of the produce. **e)** The seedlings grown under artificial condition may not survive when placed under normal environmental condition.

Methods of Micro propagation: Different methods of micro-propagation are Meristem culture, Callus culture, Cell culture, Embryo culture, Protoplast culture, Shoot apex grafting, and Pollen grain culture.

In vitro: Latin for ‘‘in glass”. Reactions, responses or experiments in an artificial environment in isolation from the whole organism **In vivo:** Latin for in living. Biological processes that occur within the whole living organism

APOMOXIS: The embryo is generally produced by sexual reproduction but there are certain cases in which the embryo is produced by an asexual process. This is of great value as the resulting plant can be reproduced by seed propagation in almost the same manner as it would be by any other vegetative method. The seedlings produced through apomixes are known as **apomictic seedlings**. Apomictic seedlings are identical to their mother plants and similar to the plants raised through other vegetative means, as it has the same genetic

make-up as that of the mother plant. Hence, propagation by means of apomictic seedlings is equivalent to vegetative propagation. The phenomenon in which an asexual reproductive process occurs in place of the normal sexual reproductive process of reduction division and fertilization is known as **apomixis.**

Kinds of apomixis: Obligate apomixis: Plants that produce only apomictic embryos are known as obligate apomicts. **Facultative apomixis:** Plants that produce both apomictic and sexual seedlings are called facultative apomicts**.**

Types of apomixis:

Recurrent apomixis: In this the embryo develops from the diploid egg cell (diploid parthenogenesis) or from some other diploid cells of the embryo sac, without fertilization (diploid apogamy). As a result, the egg has the normal diploid number of chromosomes, as in the mother plant. Eg, Onion, raspberry, Apple etc. In some plants apomixis occurs without the stimulus of pollination, in others pollination is necessary for embryo development**.**

Non-recurrent apomixis: In this type, the embryo develops directly, either from the haploid egg cell (haploid parthenogenesis) or some other haploid cells of the embryo sac (haploid apogamy). In this case haploid plants are always produced. As the plants produced by this method contain only one set of chromosomes, these are sterile and the process is not continued for more than one generation. Non-recurrent apomixes does not commonly occur and is primarily of genetic interest. Eg. *Solanum nigrum*, *Lilium spp*.,etc.

Adventitious apomixis (Adventitious embryony or nucellar embryony): In this type of apomixis the embryo does not develop from the cells of the embryo sac, but develops from any diploid sporophytic cell, eg.,cells of the nucellus (usually), integument etc. Hence, the diploid cells of the sporophyte giverise directly to diploid new embryos. This type of apomixis is found in *citrus* , where fertilization takes place normally and a sexual plus a number of apomictic (nucellar) embryos develop. In opuntia also this type of apomixis occurs.

Vegetative apomixis (Bulbils): In this case the flowers in an inflorescence are replaced by bulbils or vegetative buds, which often sprout into new plants while they are still on the mother plant. This type of apomixis is found in some species of *Allium, agave, Diascorea, pao* etc**.**

Poly embryony: This is a type of apomixis.The phenomenon in which two or more embryos present with in a single seed is called polyembryony. When such seeds are sown, more than one seedling arises from the seed .Of them one is from the zygote (Sexual seedling).The others are asexual or apomictic seedlings. The reasons for this phenomenon are many. The origin of these extra embryos or seedlings varies. 1) From nucellus-Nucellar embryony as in citrus and mango 2) From seed coats (integuments) or antipodals or synergids –rare—mango. 3) Occasionally more than one nucleus develops with in the embryo sac (in addition to the usual and regular nucleus). 4) Cleavage of the embryo during the early stages of development is common occurrence. Whatever may be the place of origin, the common thing is, these embryos arise from the maternal tissue of the plant. Eg.Citrus, Mango, Jamun, Rose, apple etc. The poly embryonic seedlings are uniform and true to parent like other vegetatively propagated plants. They are derived by mitosis, and come from maternal tissue (not by meiosis), but they have the characteristics of sexual seedlings like juvenility, vigour, freedom from virus diseases. Eg. Citrus, Mango, Jamun, Rose apple.

How to differentiate the poly embryonic and sexual seedlings: It is difficult to differentiate in the nursery. Generally more vigorous seedlings are considered to be polyembryonic. By rejecting about 10% of weaker and weakest seedlings, one can have fairly uniform poly embryonic seedlings.

GRAFT INCOMPATIBILITY: When most closely related plants are grafted together they unite readily and continue their growth as one plant. When entirely unrelated plants are grafted together, the usual result is the failure of the graft union. The inability of parts (stock and scion) of the two different plants when grafted together, to produce a successful graft union and the resulting single plant to develop satisfactorily is termed as graft incompatibility. **Ex.** Apple on pear, pear on quince and apricot and almond.

Types of incompatibility: Graft incompatibility in fruit trees has been classified in to two types. 1. Translocated incompatibility. 2. Localized incompatibility

1. Translocated incompatibility: This type involves **phloem degeneration** and this can be seen by the development of brown line or necrotic area in the bark. This is due to the movement of toxic materials through the phloem. This cannot be overcome even by inserting an intermediate stock.
2. Localized incompatibility: Incompatibility reactions are seen at the graft joint. This incompatibility can be overcome by inserting a mutually compatible interstock in between them by avoiding direct contact between stock and scion. This may be due to **repulsive action** of stock and scion.

ESTABLISHMENT OF ORCHARD: Establishment of an orchard is a long term investment and deserves very careful planning. The selection of proper location and site, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production.
Selection of site: The following factors are to be considered before selecting a site for an orchard.
1. Climate: The climate of the locality should be suited to the fruits, or the fruit chosen should be suited to the climate. Enquires should be made on the following points to assess how climate affects the fruits intended to be grown. 1) Experience of the fruit growers and research stations in the locality regarding the acclimatization of the fruits under consideration. 2) The seasons of heavy rainfall, hail storms and hot winds. 3) The seasons and intervals of cyclones, heat waves, gales and other catastrophic features
2. Soil: Few prospective sites should be examined for both physical and chemical properties. For this purpose profile pits of 2m depth should be dug in each representative part of the site as suggested by external appearance, Samples should be collected and analyzed for deciding the choice. Soil samples must be analyzed to know the suitability of soil for growing fruit crops. Soil analysis gives information on the type of soil, its fertility; its pH value etc. As far as possible flat land should be selected. There should be no hard pan up to a depth of 2 m.
3. Irrigation facilities: Most of the horticulture crops are raised under irrigation. So the water facilities should also be taken in to consideration (quantity and quality).Water table should be below 2 m depth.
4. Nearness to the market: Saves the over head charges in transport and gives close touch with market tastes (in the case of market gardens).In most cases a large percentage of the retail price of fruits is accounted for by transport charges. The hill bananas and the apples of Kulu valley are produced cheap but they are sold at high prices on the plains owing to heavy cost of transport.
5. Transport facilities: Fruits being perishable cannot be moved for long distances without quick and refrigerated transport. Bananas from the south are not reaching northern market in our own country owing to the absence of refrigerated transport. But under refrigerated conditions, they can be transported to longer distances. So; the orchards must be located where there is quick transport, preferably a refrigerated transport system.
6. Power (electricity) supply: It would be a great advantage if electric power lines are running in the proximity of the area as it can be tapped easily.
7. Proximity to established orchards: It is an added advantage if the site is in proximity to the already established orchards because of compactness of areas of production facilitates provision of transport and storage facilities. It also enables formation of co-operative societies and other associations which can collectively own grading and spraying machinery and other costly equipment including storage facilities. If there are compact blocks of single crop say citrus, banana, mango etc. the spread of diseases and pests are more. In selecting a site close to other orchards, one must make sure that they are free from devastating pests and diseases like citrus scale, canker, panama disease of banana, the tristeza disease of citrus.
8. Availability of labour: Large orchards are started often in out of the way places and forest areas away from populated centres. It would therefore be necessary to ensure that adequate labour is available for orchard operatins. This point is of important in plantation crops particularly.
9. Social factors: These assume importance when large contingents of labour and managerial staff are to be employed as plantations or large orchards. They should be provided with medical and educational facilities, so that, they are content and stick on to the jobs.

10. Presence of nurseries close by: It is an advantage if the nurseries are close by to the selected site for selecting the plants for the orchard after studying the scion parents personally. It will also help to get cheap and quick transport of plants which will ensure better establishment.

11. Cost of the land: Cost of the land comes up for consideration when all the other requirements listed above have been satisfied. It should never be the prime consideration in the choice a little extra cost paid for the foregoing amenities is more than repaid in the long run.

Orchard plan: It is of great advantage to prepare a plan of the orchard in advance, be it a home or market garden or a commercial orchard. A detailed survey of the site is carried out including the levels and a good map to scale is drawn. A full knowledge of the fruits to be grown and their cultivation is also prerequisite for efficient planning. The guiding principles in the preparation of plan are: 1) The orchard should be managed most profitably 2) It should present as attractive look as possible.

The following **general principles** may be borne in mind while drafting a plan and as many of them as possible should be fulfilled. It should be recognized that not all of them can be adopted in every case. If the entire area is not of the same type of soil, each fruit should be allocated to the soil type it prefers. The irrigation sources should be marked and channels indicated along gradients with a view to achieve most economical conduct of water. Irrigated fruits should be close to the source of irrigation to avoid long irrigation channels and consequent loss of water during conduct. Tall wind breaks should be planted especially on the sides from which high winds are expected. There should be adequate clearance between the wind breaks and the crop. Roads should be planned to occupy the minimum space consistent with economy of transport of orchard requisites and produce. The space between the wind break and the first row of fruit trees may often be utilized for roads and canals etc. with advantages.

Drains should follow the gradient of the land, should be as straight as possible and concealed from the visitors, if possible. When varieties with pollen preferences are planted they should have the pollenizer in an adjacent block or in alternate rows so as to ensure good crop set. Fruits which ripen at the same time should preferably be grouped together to facilitate easy watching and harvesting. Assign rear areas for tall trees and the front for shorter ones will besides facilitating watching, also improves the appearance of the orchard. The orchard should in general present an aesthetic appearance so as to provide marked attraction.

The spacing adopted should be the optimum. The spacing allowed is usually such that the fringes of the trees will just touch one another cutting out light but should not interlock. Within reasonable limits, closer spacing gives more yields in the earlier age. But in later life, the trees tend to grow taller than broad resulting in difficulty in pruning, spraying and harvesting. They also suffer from root competition inadequate nutrition, fewer fruits which tend to be smaller with comparatively poorer in colour development. So, adoption of closer spacing to accommodate more plants per acre proves to be a false economy in the long run. The spacing given to fruit plants depends on the following factors.

a) The habit of growth of the plant: The spacing being equal to the spread of the plants.

b) Rainfall: In the case of rain fed crops closer spacing is given in lighter rainfall areas than in heavy rainfall areas.

c) Nature of soil: Trees on stiffer soils may be given less spacing as both their top and root spread are limited in such soils.

d) The root stock: Root stock influences the spread of the trees and to that extent determines the spacing to be adopted.

e) Pruning and training

f) Irrigation system.

g) The method of layout should be fixed in advance so that the no. of plants required is worked out and arranged for.

Steps in establishment of an orchard

After the selection of the site and drafting the plan, next comes the establishment of an orchard with fruit plants. For this, the selected site should be thoroughly surveyed for studying its size, topography, flow of

irrigation water, drainage and fertility gradients. The positioning of main and subsidiary roads, wells, wind breaks etc. should be planned clearly.

Steps:

1. Clearing of the land: Preparation of the soil depends largely on its condition, previous history and grower‘s plans. If the land has been under cultivation and has been well maintained, nothing further may be required. On the other hand if the site is a new one and was never under cultivation earlier, much has to be done well in advance for planting. If the land is a virgin land i.e. it is not under cultivation previously, the existing vegetation is to be cleared. Standing trees, shrubs, bushes etc. should be cut down and uprooted along with the stumps and removed. No vegetation should be left on the site. Otherwise, they may shade the young plants; compete for water, light and nutrients. Further, their removal at a later date is expensive and risky. All the stumps and roots may be removed. Otherwise they may harbour white ants, termite hills, diseases etc. and spread to the new plants. Along with vegetation, stones, rocks and ant hills, termite hills etc. should be removed.

2. Leveling: Leveling is important for efficient irrigation, drainage to check soil erosion and also for improving appearance. If the land is sloppy contouring (if the slope is 3 to 10%) or terracing (if the slope is >10%) is to be done. During leveling sub soil should not be exposed.

3. Fencing: Fencing is necessary to protect trees from stray cattle, human trespassing and also for attractiveness. The fence may be of stone, barbed wire or live fence. Growing of live fence is an expensive one. At the initial stage it may be cheap but afterwards the maintenance is costly. Live fence needs periodical punning or trimming to shape and also to control their growth and encouraging more branching. This is one of the costly items of the orchard cultivation.

Characteristics of a good fence plant: Drought resistant, Easy to raise from seed, Quick growing, Should have dense foliage, Should stand severe pruning, Should not be hard to secature, Should be preferably thorny.

Live fences are sown at the commencement of rainy season to minimize irrigation. They are dibbled in 3 rows; 20-30 cm apart in a trench dug 60 cm deep and manured soil. Examples of **non-thorny fence plants**: Tamarind, Thevitia, Lawsonia, Casuarina, Gliricidia etc. Examples of **thorny fence plants**: Agave, cactus, Prosophis, Commiphora *barli*, *Inga dulcis* etc.

4. Wind break plants: The wind breaks are provided to resist the velocity of wind which causes loss of bloom, wind erosion and evaporation of moisture and to keep the orchard warm by checking frost and cold waves. The beneficial effect of wind break is felt up to a distance equal to 3 times its height.

The characteristics of a tree suitable as wind break are: It should be fast growing. It should be easily establish able. It should be able to acclimatize to the environment. It should have dense canopy. It should not harbour pests and diseases. It should be frost resistant. It should be drought resistant. It can be propagated by various methods. Planting material should be easily available and cheap. It should have multipurpose uses like fuel wood, fodder etc. It should with stand periodical pruning.

Wind Breaks

Some plants usually employed for growing as wind break plants are: Casuarina (Most effective in open sandy soils), *Pterocarpus santalimus* (Redsanders), *Erythrina indica* (Requires pruning to make tree top bushy), Cassia‘s and *Polyalthia longifolia* (Slow growing) are some trees which can also be used. For mango orchards, seedling mangoes and polyembryionic mangoes may be planted as wind breaks to provide chance seedlings and root stocks. There should a spacing of 12m between the row of wind break and the first orchard row. This space may be occupied by roads and drains. The wind break trees should be planted closer than their spread so as to form a thick screen. A spacing of 5 m is maximum for most of the plants.

5. Roads and drains: These are laid out according to the plan prepared in advance taking the convenience and levels into consideration. Main irrigation channels also have to be plotted. Open drains should be straight, running parallel to the gradient. Silt catching devices should be employed in the drains. Covered drains should be filled with big stones at the base and smaller ones over them and the top 12 inches should be covered with the orchard soil so as not to impede ploughing and other operations.

6. Tillage: Tillage including sub soil should be done thoroughly at this stage, since it cannot be done after planting without disturbing the roots of the trees.

7. Sowing green manure crops: A green manure crop is sown thick and uniformly all over the area to be planted. Apart from the manurial value the crop reveals by its growth, infertile patches of the land, so that they can be examined and suitable steps are taken for amending them.

8. Marking plant positions: The system of layout should be decided first. Then one of the fence lines or a road should be chosen as the base line. In deciding the base line, due regard should be given to appearance of the rows from the road along which the visitor or the manager is expected to walk.

9. Digging and filling of pits: Generally the pits are dug 2 to 3 months in advance of planting i.e. March to May. Allow the pits to weather. A planting board (a plank about 1.5m long or longer with two end notches and a center notch) is applied to the marking peg by its central notch and two pegs are driven at the end notches. Then the board and the marking pegs are removed and a pit of 1-meter cube is dug. The two pegs driven at the end notches remain in position on either side of the pit. All pits are dug similarly so that plant position is not altered at planting time. While digging, the top soil should be kept on one side and the bottom soil on another side separately: as the top soil is somewhat fertile than the bottom soil. While filling the pits, the topsoil is mixed with farmyard manure or compost, leaf mould or green leaf and a kilogram of super phosphate. Then the pits are filled with the bottom layer of soil first and then with the topsoil mixed with the manures. The soil after filling should rise about a foot over the orchard level so as to allow for shrinkage on setting.

10. Filling of pits: Filling is done a fortnight or two after digging pits. The pits are filled with a mixture of Top soil; FYM, leaf mould and bone meal. Pits are filled a few inches above the ground level for shrinkage and settlement.

11. Selection of plants from the nursery: Generally the plants are purchased from the nursery well in advance. The grower should visit the nursery and select the plants. Plants are selected on the basis of certain characters of the plants.

Branching: The main branches on the young plants become leaders on a grown up tree. These branches arise on a plant at an angle (crotch).This crotch should neither wide nor narrow but it should be medium i.e. 40-50^{O}. If the crotch is wider, splitting or breaking of limbs will occur because of heavy crop load. If it is narrow ($<30^{0}$) forms weak frame work. So plants having medium crotches are best. The branches on the trunk should not be opposite or in a whorl but alternate with at least 15 cm spacing.

Growth of the plant: The plants should be uniform in growth and is determined by uniform length of internodes. For immediate planting, plants in active growth should not be selected because they may wilt during transit and die on planting. Deciduous fruit plants should be planted when dormancy is about to terminate. They put up new growth quickly and establish early.

Age of the plants: Growers generally prefer older plants believing that these plants come to bearing early. For this there is no experimental evidence. Younger plants make up in a few years and become equally vigorous and out grow older plants. So, no benefit of selecting older plants. Choosing young plants have many advantages like cheaper in cost, easier to transport and they withstand transplanting shock and easier to transplant.

Pests and diseases: Plants should be free from pests and diseases like scale insects, mealy bugs, aphids, nematodes etc and diseases like canker, and viral diseases.

12. Lifting and packing: Before lifting of plants from the nursery the nursery is thoroughly irrigated one day in advance for easy lifting of the plants without damage to the root system. Then the plants are lifted carefully along with a ball of earth attached to the root system. The roots are wrapped in straw or grass or covered with a gunny cloth and placed in a basket or a wooden crate for packing. Depending on the size of the basket or crate 6-7 plants are kept for each basket.4-5 long bamboo splinter or wooden pegs are forked into the sides of the basket and tied at the top. In between the plants and at the top of the basket after filling, the plants recovered with straw so as to avoid falling during transit.

13. Season of planting: The distribution of rainfall in the tropics and subtropics and the break of spring growth in temperate zone determine the season of planting. In tropical climate, most trees are planted between July and December and few in January also. In general planting is done during the monsoon in moderate rainfall areas and at the close of the monsoon in heavy rainfall areas. Planting should be done on cloudy days and preferably in the afternoons rather than in the morning.

14. Planting: The planting board should be used at the time of setting the plants, so that they are in a perfect line. The plants should be set in the soil to the same level as it was in the nursery. The bud / graft joint should not be covered with soil. Plants should be irrigated once copiously to get the soil particles to closely adhere to the roots and also to drive away the air around the roots completely. The plants should be staked with a straight bamboo piece or other twig. Graft bandage should be removed if not already done. Any buds on the rootstocks should be rubbed off.

15. Heeling inn: If the plants after transport are not directly planted in the field, they may be kept in shade in a slanting position along the side of a trench moistening the ball of earth .They may be left in this position till active growth commences by which time they should be planted in the field. This process is known as healing inn.

Layout plan

- The marking of position of the plant in the field is referred as layout.
- The layout plan of the orchard should be prepared carefully, preferably in consultation with horticultural experts.
- The orchard layout plan includes the system of planning provision for orchard paths, roads, water channels and farm building.
- A sketch of the proposed orchard should be prepared before the actual planting is taken up.

Aims:

1) To provide adequate space to plants.
2) To accommodate more number of plants.
3) Easy intercultural operations.
4) System of planting

Systems of orchard plating: The arrangement of plants in the orchard is known as lay-out. The following points need to be considered before choosing a system of planting.

- It should accommodate maximum number of plants per unit area.
- It should allow sufficient space for the development of each tree.
- It enables equal distribution of area under each tree.
- The intercultural operations such as ploughing, spraying etc are easily carried out.
- It makes supervision more easy and effective.

Descriptions of the different systems:

Square system: In this system a tree is planted at each corner of a square whatever may the planting distance. The distance between row to row and plant to plant is same.

Step no. –1: ―ABCD is the area where the trees are to be planted. The first step will be establishing a base line. Select the baseline parallel to the road or fence or the boundary of the orchard. This should be drawn at half a distance of the spacing that is to be followed. For example, if the spacing is 10m, the base line should be drawn at a distance of 5m from the periphery of the plot. Step no.-2: Towards end of the base lines leave again a gap of half the spacing from the boundary or road or fence etc. and put the peg on one end of the base line. From this peg measure one planting distance and put the second peg on the base line. Thus, continue placing pegs at each of the planting distance till the total length of the base line is covered. The distance from the last peg to the boundary should also be at half the spacing. Step no.-3: From the first peg and the last peg

on the base line, draw perpendicular lines. The perpendicular lines may be drawn by adopting any of the following methods.

Cross staff method: Cross staff comprises of a wooden block with two perpendicular slits made on its surface and fixed to an iron rod. Fix the iron rod in the position of the first peg. See thorough the slit parallel to the base line and see that it lies in line with the base line. Now see through the other slit perpendicular to the first one and fix a ranging rod or a bamboo stick at a convenient distance from the base line. Extend a straight line from the position of the first peg through the position of the bamboo stick. This gives a perpendicular line to the base line at the position of the first peg.

Pythagoras theorem method: Adopting a right angled triangle with the sides and hypotenuse in the proportions of 3:4:5, a perpendicular line can be drawn. On the base line from the first peg measure a known distance in proportion of 3 and mark the point. From the first peg, measure a distance in the proportion of 4 and draw an arc away from the base line. From the point previously marked on the base line now measure a distance in the proportion of 5 and draw a second arc intercepting the first one. Now extend a straight line from the position of the first peg through the point of intersection of the two arcs. This gives a perpendicular line to the base line from the position of the first peg. Merits and demerits: 1) Most commonly followed and simplest of all and easy to lay out. 2) The possibility of cultural operations in two directions is the greatest advantage of this system. 3) The major disadvantage of this system is that a lot of space in the centre of each square is wasted.

Rectangular system: Similar to square system, except that the distance between plants in the row and distance between rows is not the same but different. Row to row distance is more than that from plant to plant in the row.

Procedure for lay out: Step nos.: 1, 2 and 3 are as same as in square system. Step no.4: Mark the planting positions on both the perpendicular lines following the spacing to be adopted between the rows. Step no.5: It is same as in square system, but following the spacing to be adjusted between the rows. Step nos. 6, and 7 are as same as in square system. Merits and demerits: It has almost all the advantages of the square system but cultivation is somewhat difficult, especially when the trees have fully grown.

Quincunx or filler system: This is also known as filler or diagonal system. This is the modification of a square system of layout distinguished to make use of the empty space in the center of each square by planting another plant is called filler tree. Generally the filler tree will be precocious and shorter duration and not be of same kind as those planted on the corner of the square. Guava, phalsa. plum, papaya, peaches, kinnow are important fillers. They yield some crop before the permanent trees come into bearing. The filler tree is removed when the main fruit trees grow to full stature and start bearing. This system is followed when the distance between permanent trees exceeds 8 m or more or where permanent trees are very slow in their growth and also take longer time for coming to bearing. Eg. Sapota, Jackfruit

Procedure for lay out: Step no-1: Lay out the square system. Step no.-2: Draw diagonals of each square. Step no.3: Mark the planting position of the filler tree by fixing a peg at the point of intersection of the two diagonals in each square. Merits and demerits: 1. The main advantage of this system is that the plant population is about double than the square system. 2. The greatest disadvantage of this system is that, it is difficult to carry out intercultural operations on account of the filler tree.

Hexagonal system: This is also called as equilateral system. Sometimes a seventh tree is planted in the centre of the hexagon, and then it is called **septule** system. In this system the trees are planted in each corner of the equilateral triangle. This system differs from the square system in which the distance between the rows is less than the distance between the trees in a row, but the distance from tree to tree in six directions remains the same. This system is usually employed, where land is expensive and is very fertile with good availability of water.

Procedure for lay out: Steps- Mark the four sides as in the case of square system with the distances shown in the sketch. Locate the positions of the plants also on the first row. Take a rope slightly more in length than double the distance between the plants. Put a knot in the centre, so that the length of the rope on either side of the knot is as much as the tree to tree distance **or** Take an iron chain with a ring in the centre and either arm

equal in length to the tree to tree distance. Hold the ends of the rope or chain, each at the positions of two consecutive plants on the first row, and stretch from the centre to give an equilateral triangle and there by the position of a plant on the second row is fixed. In this way the field can be laid out. Merits and demerits: 1. This system permits cultivation in three directions. 2. The plants occupy the land fully without any waste as in square system 3. This system allows 15% more plants than the square system of planting. 4. This system is not generally followed because it is difficult to adopt in practice in the field and the inter-cultivation in such gardens is difficult to carry out.

Triangular system: The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows. However, the vertical distance, between immediate two trees in the adjacent rows, is equal to the product of (1.118 x distance between two trees in a row). Merits and demerits: 1. This system is not much of practical importance. 2. Plants are not placed at equal distance from all sides. 3. When compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system. All the above systems are possible when the land is flat, plain or level, but not on uneven lands and sub-mountane areas (hilly areas). On undulating lands and hill slopes different types of planting systems are followed, Viz., contour and terracing.

Contour system: It is generally followed on the hills where the plants are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion. The width of the contour terrace varies according to the nature of the slope. If the slope becomes stiff, the width of terrace is narrower and vice-versa. The planting distance under the contour system may not be uniform. When the slope is <10% contour bunding is practiced and if the slope is >10% contour terracing is practiced. In this system the trees are planted along the contour line at right angles. Cultivation and irrigation can be practiced along the tree rows only. Merits and demerits: The trees may not be set at equidistance. The no. of plants per unit area will generally be less than other system.

Types of orchard

- Orchard refers to an area where intensive cultivation of fruit crops is done. **Or**
- It is an area where fruit crops like mango, citrus, papaya, banana etc. are cultivated. **Or**
- It is an enclosed area where a fruit /group of fruit trees are grown.

1. **Orcharding:** refers to growing of fruit plants in an orderly manner and maintain them for successive economic returns.

2. **Garden:** The term garden refers to fruit farm, where sophisticated agro-techniques are employed for commercial cultivation. **Specific crops:** 1. Vineyard/vinery—grape garden 2. Pinery- Pineapple 3. Orangery—Orange garden

3. **Plantation:** refers to a fairly large area where cultivation is done with a particular type of fruit crop. **Eg**: Mango plantation, apple plantation, coconut plantation etc.

4. **Estate:** refers to large area (more than 1000 acres) of sole crop cultivation. This terminology was used in earlier days (British Empire). **Eg**: Coffee estate and Tea estate.

Types of Orchards. There are various types of orcharding

1. Orcharding with single variety of a particular fruit crop.
2. Orcharding with different variety of a fruit crop.
3. Mixed orchard with different fruit crops of almost equal life span.

4. Orcharding with intercrops/intercropping.
5. Multistoried orchard.
6. High density orchard.
7. Dry land orchard.
8. Clonal orchards.
9. Homestead plantation
10. Nutrition /Kitchen garden.

1. Orcharding with single variety of a particular fruit crop: Eg: Mango orchard exclusively Alphonso variety. Pomegranate orchard of Kesar variety. Guava orchard of Sardar variety.
Advantages: 1. Purity of the variety can be maintained. 2. Convenient for planning and management.
3. All the trees come to harvest at the same time.
Disadvantages: 1. The variety may be incompatible (which leads to poor fruit set). 2. The variety may be susceptible to pest and diseases. 3. The variety may be irregular like Alphonso variety. 4. The variety may not satisfy all consumers.

2. Orcharding with different variety of fruit crop: Eg: Mango orchard - Alphonso+ Kesar+Pairi. Sapota orchard - Cricket ball+ Kalipatti. Grape - Thomson seedless+ Sonaka +Sharad seedless.
Advantages: 1. If one variety fails for some reasons other variety will give some returns/income. 2. Problem of self incompatibility can be overcome. 3. It can help in supply variety of fruits during different periods and to cater the needs of different customers.
Disadvantages: 1. Purity of variety may be affected. 2. Management and harvesting varies. 3. Mixed orchards with different fruits of equal life span.

3. Mixed orchard with different fruit crops of almost equal life span. Eg: Mango+Sapota+Guava. Tamarind+Ber+Annona+Aonla. Fig+Pomegrante+Ber+Lime. Papaya+Banana+Pineapple.
Advantages: 1. More than one crop may be available on the same piece of land. 2. If one crop fails other crop will come to rescue and maintains continuity of income. 3. Year round income.
Disadvantages: 1. Management becomes very difficult. 2. Problems of pest and diseases.

4. Orcharding with intercrop: This system involves incorporation of another species (fruit/vegetable) in between the interspaces of main crop. This system uses the open space available during pre-bearing period of main crop. The intercropping is discontinued once the main crop completely covers the canopy. The intercrop selected should have the following characters.
1. Should be compatible with main crop in their water, nutrient and soil requirement. 2. Compact stature and should not compete with main crop. 3. Short duration when compared to other perennial crops. 4. Should not act as an alternate host for pest and diseases.
Advantages: 1. Helps in getting additional income from the orchard during pre-bearing stage of main crop. 2. It also acts as a cover crop and prevents soil erosion. 3. Suppress the weed growth in open space.
4. Efficient land utilization.
Eg: Banana, Papaya, Pineapple, Guava, Phalsa, Fig, Beans, Cowpea, Dolichos, Marigold, Gaillardia, Aster

5. Multistoried orchard: Eg: Coconut+Black pepper+cocoa+pineapple. Arecanut+Vanilla+Banana +Pinapple. The principle involved in multistoried orchard is harvesting light at different height/story. The planting should be such that sunlight is harvested by different crops at different stories/levels/height and there won‘t be any competition for soil nutrients, moisture and sunlight because the spread and distribution of roots at different crop component is distributed in different layers of the soil profile.

6. High density planting / high density orcharding: Planting of fruit trees rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is often referred as 'High density planting' or HDP. This technique was first established in apple in Europe during sixties and now majority of the apple orchards in Europe, America, Australia and New Zealand are grown under this system. In this system, four planting

densities are recognized for apples viz., low HDP (< 250 trees/ha), moderate HDP (250-500 tree/ha), high HDP (500 to 1250 trees/ha) and ultra high HDP (>1250 trees/ha). Recently, super high density planting system has been also established in apple orchards with a plant population of 20,000 trees per ha. In some orchards, still closer, planting of apple trees is followed (say 70,000 trees/ha) which is often referred as 'meadow orchards'. The exact limits of plant density to be termed as is not yet well defined. It varies with the region, species, variety, rootstock, cost of planting material, labour and likely return from the orchard and agro-techniques adopted for a particular crop. High density planting is one of the improved production technologies to achieve the objective of enhanced productivity of Indian fruit industry. Yield and quality of the produce are two essential components of the productivity. High density planting aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health. The underlying principle of high density planting is to make best use of vertical and horizontal space per unit time and to harness maximum possible return per unit of inputs and national resources. In India, the usefulness / vitality of this technology has been proved in an array of fruit crops eg. pineapple, banana, papaya, mango, apple and citrus.

Advantages: 1) It induces precocity/precocious bearing 2) Higher yields. The average yield in apple is about 5.0 t/ha under normal system of planting and it is about 140.0 t/ha under high density planting. 3) Higher returns per unit area 4) Early returns 5) Easy management of orchard tress 6) Reduces labour cost resulting in low cost of production 7) Enables the mechanization of fruit crop production and facilitates more efficient use of fertilizers, water, solar radiation, fungicides, herbicides and pesticides.

Dis- advantages of high density planting: 1) HDP results in over crowding, over lapping not only in the tops, but also in the root system and heavy competition for space, nutrients and water. 2) More important is build up of high humidity, lack of cross ventilation in the orchard, which is more conducive for build up of pests and diseases. 3) Reduction in yield in the long run after 10-12 years of age. 4) Production of small sized fruits and poor quality fruits.

7. Dryland orchard: Growing of fruit plants in drylands like arid and semiarid zones as rainfed crop. This concept is gaining importance as several fruit crops have been identified for cultivation in arid and semi arid regions. **Eg**: Ber, Aonla, Datepalm, Tamarind, Fig, Phalsa etc. With the advancement of irrigation technology and efficient water harvesting and conservation some of high value fruit crops are also being grown in arid and semiarid/rainfed regions. **Eg:** Mango, Grape, Pomegranate etc.

8. Clonal orchard: Orchard established from plants derived from single individual mother plants through vegetative means. **Eg**: Clonal orchard of mango var. Alphonso. **Advantages:** Plants will be uniform in growth, bearing habit and management practicese

9. Homestead Plantation Plantation is done in the premises of the house/bungalow compound is referred a homestead plantations. It is a system of crop production for diverse uses of family members. Homestead plantation is very common in South-Indian state. Coconut-banana/cocao-turmeric/ginger/cassava/pineapple etc. are planted in available land spaces in house compound

TRAINING AND PRUNING: Training and pruning are important operations. Both the operations form an indispensable process having direct bearing on growth and vigour of plants and yield and quality of fruits.

A properly trained and pruned plant sustain heavy crop load and produce bounteous harvest of quality**.**

Training refers to the judicious removal of plant part / parts to develop proper shape of a plant capable of bearing a heavy crop load whereas **pruning** is defined as the judicious removal of plant parts like root, leaf, flower, fruit etc.to obtain a good and qualitative yield. Thus, it can be conceived that the **training** is related to shape and size of plants where as **pruning** is related with harvesting better yield and more so harvesting fruits of quality. Both the operations of training and pruning work together in maintaining shape and size of tree and harvesting desirable yield. **Training** is a treatment given to the young plants to get a suitable or desirable shape with strong framework. It may or may not involve pruning.

Pruning is the removal of unwanted, surplus annual growth; dead, dried and diseased wood of the plants is called Pruning. **TRAINING:** Before actually discussing the subject of training, it is necessary to understand the various terms used to make the subject more intelligible. **Trunk:** The main stem of the plant. **Head:** The point on the trunk from which first branches arise. **Scaffold branches:** The main branches arising from the head are known as scaffold branches. Trees in which scaffold branches arise within 60-70cm height from the ground level are called **low head trees** and those in which they come out from the trunk above 120cm are called **high head trees**. **Crotch:** The angle made by the scaffold limb to the trunk or the secondary branch to the scaffold limb is called **crotch**. **Leader:** The main stem growing from ground level up to the tip dominating all other branches is called **leader. Water shoot:** A vigorous growing unbranched shoot arising on any branch or leader is called **water shoot. Water sucker:** The growth appearing on rootstock portion is called **water sucker.**

The reasons for training fruit trees, ornamental trees, shrubs etc. are: 1) There are no. of plants, which grow wild and don't bear if they are left to themselves and will not have any symmetry in their growth. 2) Most of the time, the unpruned trees put forth vegetative growth only. Hence, bearing will be delayed. 3) When plants are grown in rows at close spacing, they grow tall and occupy interspaces, making intercultural operations difficult to practice. 4) For want of sunlight, the lower branches wither and die. The shaded fruits (**apple, citrus** etc.) fail to develop colour. 5) Untrained trees will generally be less productive because of excessive vegetative growth for most of the time. 6) The framework being weak in untrained trees, it breaks easily due to strong winds as well as heavy loads of crop. All the above problems can be overcome by training the trees. Man can train the plant to suit his desire. By training the plants, ideal conditions a can be provided for better production. The fruit trees are trained to a particular system depending upon their habit of growth and the flowering and ornamental shrubs etc.can be trained to a particular shape like animals, birds etc. It is necessary to pay attention to the training of a plant during the first few years when it is young. In this period, its permanent framework is built up as decided upon by the grower.

The main objectives to be kept in view in training the fruit trees are: To facilitate orchard cultural operations. To provide an attractive appearance. To admit more light and air to the centre of the tree and to expose maximum leaf surface to the sun for increasing production for complete colour development To protect the tree trunk from sunburn injury. To secure a balanced distribution of fruit bearing parts on the main limbs of the plant. Most deciduous and evergreen woody trees are best trained to a single stem with a low head. In case of pomegranate, custard apple and fig it would be better to train two or three stem plant and remove the other stems that may grow later. In the tropical climate, the high-headed trees are unsuitable as their exposed trunks are subject to sunscald in summer. Low headed trees are common all over the world. In such trees the heads or crown is kept so low on the trunk that there is only a distance of 60-- 90cm (2—3 ft.) between the ground and the lowest branch. Such low headed trees come in to bearing comparatively much earlier, are able to resist stormy winds more effectively and their spraying and harvesting also become easy. The formation of the main frame work of the tree is the most important part of the training.

1) Usually, two to four main branches are encouraged. These should be allowed to arise from different directions and also at some distance from one another, so as to form a well-balanced head. 2) The frame work is greatly strengthened, if the branches are spaced at about 15cm distance with medium crotches (40—50^0) 3) If two or more branches of equal size are allowed to arise from one place, they form a bad crotch and often split from their common joint. The most important systems **of training** followed in most of the fruit crops are:

Central Leader system: In this system, a tree is trained to form a trunk, which extends from the surface of the soil to the top of the tree. In many kinds of trees, the central axis or the main branch naturally grows vertically upwards and smaller side branches grow from it in various directions. If the central leader is allowed to grow indefinitely, it will grow more rapidly and vigorously than side branches resulting in a robust close centre and tall tree. In such a tree the bearing is confined in top portion of the trees.

Merits and demerits: 1) The main advantage of this system is the development of strong crotches. 2) Its main disadvantage is shading of the interior of the trees. This weakens the central leader and thus shortens the life

of the tree 3) Since trees are very tall, harvesting and spraying become difficult and costly. 4) The lower branches, which remain more or less shaded, become ultimately less vigorous and less fruitful. 5) Owing to the shading of the inferior, the bearing surface moves to the periphery (outer shoots) of the tree. Thus fruiting surface is reduced and eventually yields are reduced. 6) The very high shape of the plants makes them prone to wind damage. 7) This method of training is not suitable for high altitude and hot arid places where wind velocity is high. This system is also called as close centre, since the centre of the plant is closed and also as pyramidal system, since the plant trained looks like a pyramid. This system of training is practiced in case of certain apple varieties and pears.

Open Centre system: In this system of training, the main stem of the plant is allowed to grow only up to a certain height by **beheading** it in the young stage i.e. within an year of planting and inducing all the subsequent vegetative growth by lateral branches This results in the **low head** in which the bulk of the crop is borne closer to the ground than in case of central leader tree.

Merits and demerits: 1) It allows more light to reach all parts of the tree which is helpful (a) for better colour development of the fruit (b) fruiting area is spread all over the area of the trees. 2) Trees become low headed. So, pruning, spraying, harvesting etc., are facilitated. 3) The branches form weak and narrow crotches, which may frequently break under severe stress and strain such as bearing of heavy crop and strong winds. 4) Sun scalding of central leader is also possible. 5) The branches form very close to each other all most from the same spot. 6) In this system the plants take a '**bowl or vase'** shape, which provides a good base for setting of frost. So this system is not suitable for high altitude areas where frost observance is common. Since the main axis is removed, it leaves the centre open and hence **open centre** and the tree looks like a **vase (bowl),** hence it is otherwise called as **vase system**. This system of training is practiced in **plums** and **peaches**.

Modified Leader system: This is intermediate between the above two systems and has the advantages of the both. This system is developed by first training the tree to the leader type allowing the leader to grow unhampered for the first four or five years. The main branches are allowed to arise on the main stem at reasonable intervals. After the required number of branches has arisen, the main stem is headed back and lateral branches are allowed to grow as in the open centre system.

Merits and demerits: 1) This results in a low-headed tree with well-spaced limbs, well distributed fruiting wood and low height to carryout orchard operations conveniently. This system of training is practiced in fruit plants like **citrus, pear, apple** and **walnut** etc.

Which system of training is the best? Among the above three systems of training, the modified leader system is the best and most desirable because: Narrow to medium crotches and there by breakages are eliminated The indeterminate growth of the central axis is also prevented keeping the tree height under control, so as to make orchard operations easy and cheap**.** No danger of sun scorching and fruit quality is good.

Principles of training: Irrespective of the system of training practiced, the following general principles are to be observed: 1) The branches should arise on the main trunk alternatively at intervals of at least 15 cm and not all at one place. 2) They should be equally distributed around the stem. 3) Up right branches should not be encouraged. Branches should have medium crotches.

PRUNING: Pruning may be defined as the removal of any excess or undesirable branches, shoots, roots, or any other parts of a plant, so as to allow the remaining parts to grow normally or according to the desire of the pruner. Pruning is the removal of unwanted, surplus annual growth, dead, diseased, dried and broken branches of the plants. Pruning is an art of removing scientifically certain portions of a plant with a view to producing more and superior quality of fruit. Pruning of any kind according to its severity, changes the nutritive conditions within the tree and consequently, limits or encourages fruit bud formation.

Reasons for pruning There always seems to be surplus branches on a tree. But only those, which are useful to the plant in holding up the leaves to the sun to grow strong. Those which will have little chance of doing so, because of shade or other reasons become weak and eventually dry up. Evidently the plant is making a selection and eliminating the useless branches. But this process of selection and elimination is a

slow one. Till they are eliminated the useless branches also draw some nutrients which is a waste for the tree ultimately. If such branches are recognized and eliminated earlier will help in conservation of food in the tree for better production. The second reason for pruning will be the removal of diseased twigs to check the spread of diseases In some fruit trees, fruits are borne on current flush (Ber, Grape etc.) which will be obtained in large number after pruning of certain no. of old branches.

Objectives of Pruning: 1) To remove the surplus branches and direct the sap flow in to the remaining branches. 2) To develop a strong frame work which can carry the load of a good crop and can with stand strong winds. 3) To train the plants to a definite shape. Ex. Fence, Hedge, Topiary etc. 4) To thin out branches so as to admit more light into the interior of the tree top so that the inner wood also becomes fruitful. 5) To limit the size of the tree top to a convenient one so as to render spraying and picking more easy and economically. 6) To regulate the spacing and distribution / direction of branches. 7) To distribute the fruiting wood in all directions and to maintain a balance between vegetative and reproductive phases. 8) To improve the growth of the spur (A short lateral branch one inch or less in length with nodes close together, so that the leaves converge to form a rosette) shoots and production of more flower buds. 9) To check the further spread of the diseases. 10) To maintain the vigour of the plant by removing the water shoots and other unwanted growth.

Responses of plants to pruning: The response of plants to pruning should be well understood for successfully achieving the object of pruning. The following are the some of the important ways in which the plants show response to pruning. **1. Activation of buds:** When a branch is cut or pruned, the buds on the branch below the cut are invigorated (activated). The bud close to the cut is most vigorous and this vigour decreases in the buds as the distance increases from the cut. This is due to the elimination of the apical dominance of the terminal bud from which the auxin flows down and inhibits the growth of the lateral buds.

This response is made use of to determine the direction of the existing branches and correcting a crotch. If the crotch is a narrow (The angle between the branch and the stem on which it arises –Crotch), the branch is pruned to an outer bud, so that the bud will produce a branch towards the outer side usually at right angles to the branch or nearly so. As it grows larger, it pulls away from the stem and eventually widens the crotch. Similarly, a wide crotch can be narrowed down by pruning the branch to an inner bud.

2. Dwarfing response: The immediate effect of pruning is no doubt invigoration of new branches owing to the diversion of food, but due to removal of much foliage, there is an overall reduction in the manufacture of food resulting a shock on root growth. This in turn limits the further growth of the new shoots. When the growth of the new shoot is reduced, their length is also reduced. Therefore, the net effect of pruning a tree is dwarfing, which is in proportion to the severity of pruning. Both the spread of the top as well as the spread of the root system are reduced. This also results in dwarfing of the plant.

3. Production of water shoots: Severe pruning often activates resting or adventitious buds and buds on old wood may sometime be stimulated to grow. They often produce branches, which grow vertically and very vigorously with **long internodes**; **angular stems large succulent leaves** and **thorns** (as in citrus). They are called **water shoots** or **water suckers** or **bull canes**. These highly vegetative water shoots are seldom fruitful till they are several seasons old. They are wasteful and unwanted because they draw much food and grow at the expense of the fruiting wood and are better removed as soon as they appear. However, they may be profitably used in some instances to fill in the gaps occurring in trees by lopsided development or loss of branches due to other causes. Eg. Citrus, Guava, Ber, Sapota, Cashew etc.

4. Delay in bearing: When pruning is severe particularly in early years of the fruit plant, bearing is delayed. Sometimes severe pruning may also lead to poor yields, because a major portion of the foliage and fruiting wood are lost.

Methods of pruning

1. Thinning out: When a shoot is removed entirely from the inception (from the point of origin) so that, no new shoot arises from that place, it is referred as **thinning out**. This thinning is practiced in the removal of shoots arising in unwanted places, water shoots etc.

2. Trimming: Cutting the growth of the twigs to a pre-determined level as in the case of fence, hedge and edge.

3. Heading back: When the branches grow tall and vigorously without producing flowers, these shoots are headed back. When a branch is cut almost to the base, leaving a few inches of stump, carrying few buds, it is referred as **Heading Back**. These buds left on the stump will give rise to shoots which are important to the tree either being spur bearers or bearing flower buds or filling up of gaps in the tree or forming vegetative wood from which flowers may arise in the following year. The shoot from the bud nearest to the cut takes the place of the pruned shoot.

4. Pollarding: Mere cutting back of the shoots, indiscriminately to reduce the height of the tree is **Pollarding**.

5. Pinching (tipping): Removal of the tip of the shoot to stop its indeterminate growth or to encourage the growth of the lateral buds is **pinching or tipping**. This is practiced in marigold and chillies at the time of transplanting.

6. Disbudding (nipping or rubbing): Nipping or rubbing of young buds preventing a chance of their sprouting is **disbudding**. When the buds arise in wrong places they are rubbed off. Similarly sprouts (Buds) on root stocks are disbudded.

7. De-blossoming: Removal of surplus flowers to enable the tree to produce crops regularly year after year is called **deblossoming**. This is practiced in alternate bearers like mango. apple etc.

Seasons of pruning: 1. It depends on the type of wood, type of plant species and time of flower bud formation. 2. Removal of diseased, dead, and dried wood as well as water shoots can be carried out at any time of the year. 3. Pruning of healthy branches should not be done when the trees are in flowering or fruiting, since the resulting disturbance leads to loss of blossoms or fruits. 4. In deciduous trees, pruning can be done before the termination of dormancy. 5. In ever greens, pruning should be carried out before the start of active growth or after the harvest of the crops. 6. Summer pruning of deciduous trees and also the pruning of evergreens in the active growing season delays the formation of flower buds by prolonging vegetative growth.

Pruning and Manuring: The sudden invigoration of a number of buds due to pruning makes a demand on the food resource of the tree, because the new shoots are not yet ready to manufacture their own food. The reserve food in the plant often may not be sufficient to meet this demand of new growth. Further, pruning means loss of much foliage and wood. So, to compensate the loss incurred due to pruning and to meet the demand of new shoots the pruned trees should be manured heavily, otherwise the new shoots ultimately wither and dry. This is particularly important when old (Senile) or neglected trees are pruned for rejuvenation.

Care of pruned wounds: Pruning leaves wounds and cut ends which should be protected to avoid the access of disease pathogens and insect pests through these wounds and cut ends. So, immediately after pruning, these cut ends and wounds should be protected by applying disinfectants like Bordeaux paste or blitox paste.

Unfruitfulness in fruit trees – Causes and remedies

1. **Environmental causes:** 1) Some varieties of a fruit crop don't flower in a locality owing to undetermined environmental factors eg. several north Indian varieties of mango have not flowered in south India. This can be remedied by top working with south Indian varieties. 2) Unfavourable temperature may cause failure of any flowering as in the case of apples in conoor due to lack of sufficient winter chilling. It has been remedied to certain extent by oil emulsion sprays and DNOC (Di-nitro-ortho cresol). 3) In tropics, plants flowering in summer may experience retarded pollen germination due to high temperatures and low humidity. The provision of wind breaks, close planting and cover cropping help in improving the situation. 4) Reduced illumination due to close planting , overcrowding of branches or shade will often reduced flowering Thinning out some trees to increase spacing, pruning trees to reduce overcrowding and removal of shade can meet the situation. 5) When long day plants of northern latitudes don't flower owing to the absence of the critical length of day, they can be made to flower by providing artificial light. On an orchard scale such treatments are not practicable. 6) Late rains may prolong the vegetative growth and delay or reduce flowering in mango.

It can be remedied by drying out the soil by deep ploughing and probably by artificial inhibition of growth by growth regulators. 7) Heavy rains may restrict pollinator activity, wash away pollen and prevent pollen germination. Choice of varieties which don't flower at such periods of the year is the best way out. In crops like grapes, the pruning time may be altered to avoid the onset of flowering during the period of the rainy season crop may altogether be avoided by hard pruning.

2. **Nutritional Causes**: 1) Heavy nitrogenous manuring at the time of flower bud initiation often reduces flowering by promoting vegetative differentiation. The practice should be given up. Root pruning and restricted irrigation may be helpful in reducing vegetative vigour and inducing formation of male flowers. 2) Over bearing in the previous season exhausts the tree and reduces subsequent flowering as in mango and most biennial bearing trees. A complete manure mixture applied at the growth flush following the harvest will be helpful (June manuring in mango). 3) Lack of nutrition as in weak shoots causes fall of flowers before and after fruit set. A spray of urea after fruit set will help the development of fruits. 4) Lack of sufficient reserves of carbohydrates in shoots may cause sparse flowering and poor set (shoot bunches of grapes).Ringing and girdling may help. But it should not be continued as a regular orchard practice. 5) Adverse growth features like water suckers will result in a drain on the tree and reduce flowering not only on themselves but also on other branches of the tree. Such shoots arise when big branches are pruned. Then it is necessary to cut big limbs, they should always be set to a strong lateral but not stimulate a dormant bud. Late irrigation following a long drought may cause the production of water shoots. The first irrigation after a drought should always be sparing later ones being more liberal .When water suckers are formed due whatever reason, they should be promptly removed. 6) Deficiencies of elements are sure cause of reduced flowering as well as set. A composite mineral spray at flush time will usually be very helpful. If deficiency is due to alkalinity of the soil, suitable reclamation measures should be adopted. 7) Heavy manuring and severe pruning during the pre-bearing period will prolong it. Pruning should be done while branches are young, preferably by rubbing of axillary buds themselves by frequent observation of the plants. Seedlings and some species of plants have a long prebearing period during which no undue anxiety should be felt for hastening flowering. Old trees suffer from inadequate nutrition especially when they are neglected. The short extension of shoots, small leaves showing various deficiencies, scanty leaves and die back of shoots indicate approaching death. Such trees may be given one chance to bear by (1) manuring them heavily with a complete mixture of nutrients (2) pruning hard up to 3-4 year old wood and (3) spraying a composite mineral mixture on young flush. Irrigate frequently and protect them from pests and diseases. This may rejuvenate the tree for a few years.

3. **Inherent Causes:** 1) Low proportion of female or perfect flowers as in some varieties of mango (Jehangir, Allampur baneshan etc.) often is the cause for a poor crop. There appears to be no remedy for this defect. 2) Structural features like heterostyly and habits like dicho-gamy some times restrict the availability of pollen and pollination. The presence of sufficient population of the tress and pollinators ordinarily ensures good pollination and set. 3) Inadequate quantities of pollen appear to reduce fruit set in some varieties of strawberry and some varieties of grape. Use of suitable growth regulators to get fruit setting will circumvent the difficulty. 4) Many varieties of Japanese plums and apples are self sterile. Many other fruits also partially self sterile .So planting varieties which make them fertile with their pollen will solve the problem. 5) When intersterility is the cause for low fruit set compatible pollenizers have to be provided. Mixed pollen sprays and use of synthetic growth regulators may also be helpful. 6) Triploidy and distant cross are often reasons for low fruit set. Chemical aids can get over the problem. 7) Defects of ovule development, embryo abortion etc.are observed in dropped flowers. These largely seem to be varietal characteristics and cannot largely be altered.

4. **Bio-logical causes:** 1) Absence of pollinating agents can be a reason for low fruit set in several fruits. Rearing bee colonies in orchards, besides being a subsidiary source of income greatly helps fruit set. 2) When specific insects' symbiotic adaptations (like the blastophaga for fig) concerned with the pollination, they must be reared (by growing Capri fig trees in this case). A wooden needle seems to perform the duties of the blastophaga quite as efficiently in promoting set of fig fruit. 3) Pests like the mango hopper which

directly attacks the flowers obviously reduce the fruit set. Others which feed on leaves reduce the photosynthetic surface impair production of carbohydrates and thus reduce flowering. Several fungal diseases do the same thing; Suitable remedial measures should be taken to protect the tress.

5**. Cultural causes:** 1) The commonest cause of poor flowering in house gardens is excessive irrigation which restricts aeration of roots and causes sickly symptoms. Increase of intervals of irrigation and provision of drainage are the remedies. 2) Weeds and intercrops may compete with the main crop for nutrition and water in low rainfall areas .Removal of weeds and adequate manuring to meet the demands of both the fruit crop as well as the intercrops are helpful. Intercrops which clash with the irrigational and manurial requirements of fruit crops both in respect of quality and time of application should be avoided. 3) Ploughing or deep cultivation at flowering time will result in drop of flowers and should be avoided. 4) Severe pruning of large limbs which encourages production of water shoots should be avoided. If it is absolutely essential, the branches may be cut to a strong lateral. Wrong pruning techniques may also cause reduction of flowering. The following points should be borne in mind (1) the pruning should be with regard to bearing habit of the fruit tree, (2) the pruning should be up to some fruitful buds (in grapes). Harder or light pruning will reduce fruiting, (3) a balance of vegetative and fruiting wood should be maintained in plants bearing on past seasons wood, (4) pruning should not be delayed till the new growth is resumed. In practice good drainage, timely irrigation, manuring and culture and selection of suitable varieties will ensure good set of crops.

USE OF PLANT GROWTH REGULATORS IN FRUIT PRODUCTION

Growth mainly refers to the quantitative increase in plant body such as increase in length of the stem and root, the no. of leaves, the fresh weight and dry weight etc. On the other hand, germination of seed, formation of flowers, fruits and seeds, emergence of lateral buds, falling of leaves and fruits are qualitative changes, referred to as development. Growth and development of the plant body are controlled by two sets of internal factors, namely, nutritional and hormonal. Nutritional factors supply the plant necessary mineral ions and organic substances such as proteins, carbohydrates and others. These constitute the raw materials required for growth. However, utilization of these substances for proper development of the plant is controlled by certain chemical messengers, called plant growth substances or plant growth regulators, which in minute amounts increase or decrease or modifies the physiological processes in plants. The term plant growth regulator is relatively new in use. In earlier literature these were mentioned as Hormones. Hormone is a Greek word derived from **hormao** which means to stimulate. Now the term phytohormone is used in place of plant hormone. Plant growth regulators or plant regulators are the organic compounds other than nutrients which modify or regulate physiological processes in an appreciable measure in the plants when used in small concentrations. They are readily absorbed and these chemicals move rapidly through the tissues when applied to different parts of the plant. Plant hormones or phytohormones are also regulators but produced by the plants in low concentrations and these hormones move from the site of production to the site of action. Therefore, the difference between the plant regulator and plant hormone is in that the former one is synthetic and the latter one is natural from the plant source.

The various types of growth regulating substances are: Auxins Gibberellins Cytokinins Ethylene Abscisic acid. Auxins, Gibberellins and cytokinins are **Growth promoters** and Ethylene and Abscisic acid are **growth inhibitors**. **Growth Retardants:** These are chemicals which have common physiological effect of reducing stem growth by inhibiting cell division.

Growth regulating substances have many practical applications in horticulture and some of the most important uses are: **1, Propagation of plants:** The most common use of plant regulators in horticulture is to induce rooting in stem cuttings and in air and soil layers. ***Rooting of cuttings:*** Certain kind of plants may not successfully root under normal condition and with the aid of plant regulators; they can be easily made to induce rooting. The most commonly employed growth regulators for rooting are auxins like IBA, IAA, IPA and NAA. Among these chemicals IBA is most ideally used since, it is the most effective one. Concentrations ranging from100-500ppm are used for long dip method of treatment of cuttings for 12-24 hours and high concentrations of 10,000 to 20,000 for quick dip method for a few seconds. The concentrations differ according to the type of cutting i.e. herbaceous, Semi-hard wood and hard wood

cuttings. Applications in the form of dust as talcum preparation or in the form of a paste in lanolin are also used. ***Layering:*** Another usage of plant regulators in plant propagation is in aiding rooting of air layering. Layering is the practice of inducing rooting on shoots/stems while it is still attached to the parent plant. This is practiced in fruit trees like guava, pomegranate etc. The main principle of layering is that a part of the aerial portion of the intact plant is girdled. This results in severing of phloem. Consequently, hormones and food substances coming from the leaves accumulate above the girdled portion. When the ring of bark is removed from the stem, the growth regulators like IBA or IAA in power or in Lanolin paste is applied at the distal end of the bark-removed portion to promote root formation ***Grafting and Budding:*** Grafting of plants is a widely used horticultural practice of multiplying the desired genotypes in mango, citrus and others. For this, a portion of the plant is inserted in to another plant of the same species or some times compatible plants of different species or genera. There are mainly two types of grafting: bud grafting and scion grafting. Whatever may be the method employed, the principle remains the same. When the cambium of a stock plant comes into physical contact with the cambium of a scion both from new xylem and phloem simultaneously together. Consequently, these become united and grow as one plant. Since, auxins have the property of promoting cell division of cambium these are often employed. Before grafting, either stock or scion or both are dipped in auxin solution. This promotes an early union and consequently, a better success of grafted plants. 2. **Control of flowering:** The plant growth regulators are used for the regulation of flowering in certain crops. In pineapple flowering is irregular and harvesting becomes a problem and hence to regulate flower production, plant regulators are used. The treatment generally consists of pouring a required quantity of (50ml), the solution containing 0.25 to 0.5 mg of the chemical of NAA in the central core of plants. In recent studies, Cycocel and Alar at 5000ppm and Ethrel at 100-200ppm have been shown to induce flowering in mango during an off year. In *Jasminum grandiflorum*, the flowering period is extended by the application of Cycocel at 500ppm. Flowering can also be induced in certain vegetables such as radish, beet root and carrot with the application of GA. **3. Fruit set:** Various growth regulators like IAA, IBA, IPA, NAA, 2, 4-D, 2, 4, 5-T and GA have been found to improve fruit set in many crops. Among these chemicals 2, 4-D and NAA (Planofix) have been found in general to be most effective in increasing the fruit set. The optimum concentrations for this purpose are 10-20 ppm of auxins and 10- 100ppm of GA in different crops. Spraying the flower cluster thoroughly 4-6 days after full bloom with 100 ppm GA increased the fruit set in grape. It has been found that in chillies spraying of Planofix @ 1ml in 4.5 litres of water at 60th and 90th day after planting is beneficial for good fruit setting. **4. Fruit drop:** Losses resulting from pre-harvest drop of fruits have long been a serious problem. When the growth regulators have been put in to use in apples and pears, preharvest fruit drop can be checked by the application of 2,4-D and 2,4,5-T effectively. Pre harvest fruit drop in citrus is controlled with 2,4-D at a concentration of 20ppm2,4-D, 10- 15ppm of NAA and 2,4,5-T at 15 to 30ppm at pea stage and marble stage and 2,4D at 20ppm and 2,4,5-T at 10-15ppm in mandarins. At 10ppm and NAA at 20ppm have effectively prevented fruit drop in mango. Application of planofix containing NAA at pea seed and marble size of the fruits completely controlled early fruit drop in Guava.

5. Parthenocarpy: Partenocarpic fruit set could be induced in a no. of vegetables like cucurbits, bhendi, brinjal, chillies and tomato and fruits like guava, straw berry, citrus, watermelon etc.IAA, IBA, NAA, NOA, NAD, 2,4-D, IPA and GA are effective in different plants. Application of GA at 100 ppm induced complete seedlessness in grape varieties Viz., Anab-e-shahi, Pachadraksha etc. The problem of development of seeds in Poovan variety of Banana in Trichy area of Tamilnadu is controlled by application of 2,4-D at 25ppm in the bunches when the last hand is opened. **6. Fruit ripening:** The plant growth regulators can be employed to hasten or delay fruit ripening. Plant growth regulators like 2, 4, 5-T at concentrations of 25 to 100ppm has been found to hasten the ripening in some varieties of plums and peaches. In banana ethrel treatment at 2500ppm induces ripening in 24 hours. Application of 2, 4-D at 16ppm delays ripening in Washington navel oranges. In Calymirna fig maturity and ripening of the fruit is greatly hastened by spraying 2, 4, 5-T, while in apples in addition to this B-Nine also hastens ripening by about 1-4 weeks. Ethephon has been shown to hasten ripening in grapes. In tomatoes all fruits on a plant won‘t mature and ripen at a time .This is a serious disadvantage for mechanical harvesting .Ethephon applied 1-2 weeks before harvest promotes degreening

and ripening of tomatoes. Application of smoke is commercially employed to hasten and ripen bananas, the active ingredient responsible being ethylene. Ethyphon is also employed for degreeing and colour development of harvested fruits. **7. Fruit size and quality:** Increase in berry size in Anab-e-shahi,Kismis and Bhokri varieties was reported when GA was applied at 40ppm at bud and flower stages. Higher concentrations resulted in the increase in the length of berries. **8. Sex expression:** Plant regulators can be employed to modify the sex expression in crops. In cucurbitaceous vegetables the production of male flowers will be always more in number than the female flowers and this sex ratio can be narrowed down by the application of ethrel at 100 to 250ppm, if sprayed four times at weekly intervals commencing from 10 to 15 days after sowing. This growth regulator not only increases the number of female flowers to male flowers, but also produces female flowers at earlier nodes. Application of GA, the sex ratio is shifted towards maleness in several cucurbits. Certain plant regulators are employed to induce male sterility in crop plants, so that such male sterile plants can be used as a female plant in the hybridization work. This process dispenses the expensive work. Complete male sterility in bhendi can be obtained by spraying with 0.4% of MH. A single spray one week before floral bud initiation offers male sterility for 10 days and a subsequent spray at floral initiation extends the effect to 22 days.

Preparation of growth regulators Solution form: To prepare an alcoholic solution of any plant growth regulator, dissolve 1 gm. of growth regulator in 50 ml of ethyle alcohol or methyl alcohol or methylated spirit and then dilute this with an equal volume of water to make 100ml of solution containing 10,000 ppm of growth regulator. This acts as stock solution for further dilutions with distilled or de-ionized water. Stored in well-stoppered bottles in a refregirator, the solutions retain their activity indefinitely. **Dust form:** To prepare a dust containing 10,000ppm of growth regulator dissolve 1 gm of the regulator in 40 ml of methylated spirit of 95% alcohol and stir this into 100g of pharmaceutical talc to form a smooth paste. This should be done in a dark room away from strong light. Stir the paste while it is drying until it becomes a fine dry powder. This prepared dust remains active for six months or more if stored in a closed opaque container in a refregirator. From this stock, before using, dilute the growth regulator by mixing the stock with talc powder. **Lanolin pastes:** These are particularly convenient for use in air layering but now regarded as an obsolete treatment for cuttings and are made by stirring the growth regulators into the molten lanolin and then allowing it to cool. To make a paste containing 5,00ppm of growth regulator melt 200gm of lanolin and thoroughly stir into this molten lanolin 1gm of required growth regulator. This prepared paste will keep indefinitely if stored in a well stoppered opaque glass vessel in a refrigerator.